1804

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UC-41 - Health and Safety

APPLIED HEALTH PHYSICS

ANNUAL REPORT FOR 1958

OAK RIDGE NATIONAL LABORATORY
U.S. ATOMIC ENERGY COMMISSION

OAK RIDGE NATIONAL LABORATORY

operated by

UNION CARBIDE CORPORATION

for the

U.S. ATOMIC ENERGY COMMISSION

1804

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HEALTH PHYSICS DIVISION

APPLIED HEALTH PHYSICS ANNUAL REPORT FOR 1958

J. C. Hart, Section Chief

DATE ISSUED

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Oak Ridge, Tennessee
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1.0 Introduction

1.1 Discussion

At ORNL it has been recognized from the very beginning that ionizing radiation is harmful to man under conditions of excessive exposure. Consequently, it has been a long standing policy to provide reasonable assurance that recommended levels of maximum permissible dose shall not be exceeded. As a result, operating procedures are devised which will limit radiation exposure to the lowest practical level in order that a maximum of permissible exposure is available should an emergency arise and/or an accident occur. Exposures are minimized by budgeting the time of workers, erection of shields, and use of remote handling equipment.

1.2 Permissible Exposure Levels

The maximum permissible exposure levels are based on the recommendations of the ICRP and the NCRP as described in NBS Handbooks 52, 59, and supplementary reports. Normal Laboratory operations are planned in such a manner as to guarantee that no employee will exceed either the maximum dose in a 13-week period or the accumulated dose permitted under the provisions of the age formulas. It is the general practice for supervisors to budget the working time of the employees constituting a work group in such a manner as to minimize the exposure to any one individual.

Normally, planned exposures are limited on a daily and weekly basis in such a manner as not to exceed the average permissible dose established by the age formulas. Thus, the normal planned exposure, when averaged over a 13-week period, is only a fraction of the permissible quarterly dose. If it becomes necessary in the course of an operation to utilize all of the dose permitted on a quarterly basis, exposures are permitted at the recommended permissible quarterly rate providing the accumulated dose does not exceed the levels recommended in the age formulas.

In the event of an accident leading to an exposure which exceeds the recommended maximum permissible quarterly dose and/or the accumulated dose provided for in the age formulas, the employee is not permitted additional exposure until sufficient time has passed to reduce the accumulated dose to the recommended permissible average.

1.3 Radiation and Contamination Control

It is mandatory in planning Laboratory operations to consider the recommended maximum permissible levels as they apply to employees, persons residing in the vicinity of the Laboratory, and the population at large.

In regard to occupational exposures, it is essential to assure that the radiation background resulting from normal Laboratory operations be minimized in order to permit as much freedom as possible in the planning of work assignments. In order to accomplish the above, it is Laboratory policy that the radiation background within the Laboratory premises will not persist for a significant period of time at a level greater than 1/10 of the recommended permissible occupational exposure. Consequently, extensive monitoring is performed on a Laboratory-wide scale to assure that contamination of air, work clothing, and Laboratory equipment is such as to guarantee that the above criterion is met. If it develops that the above criterion cannot be met, operations are decelerated, equipment decontaminated or replaced, and/or the area of concern isolated as a controlled zone.

In order to assure that the recommended maximum permissible levels are not exceeded in the case of persons living in the neighborhood of the Laboratory area and/or in the case of the population at large, a network of air monitoring stations capable of determing the radioactive content of the air, is maintained. In addition, surface streams are monitored routinely in order that the recommended maximum permissible levels for water are not exceeded.

1.4 Responsibility for Radiation Protection

It is Laboratory policy that overall responsibility for a safe operation lies with the immediate supervisor in charge of the operation. The supervisor is responsible for keeping up-to-date with the exposure record of the employees under his supervision; he is aware of all potential hazards involving the operation; and he is expected to plan the work of his department in such a manner as to minimize radiation problems. In matters involving the exposure of personnel to ionizing radiation, the supervisor is assisted by a professional health physicist who recommends working time, protective equipment, and (in some cases) operational methods.

Radiation monitoring activities which include personnel metering, background measurements, and environmental surveys are the responsibility of the Health Physics organization and are discussed in this report.

2.0 Area Monitoring

H. H. Abee W. D. Cottrell

2.1 Statistical Summary

The average levels of air contamination in the Laboratory area were less in 1958 than in 1957; the levels in the neighborhood of the Laboratory out to the perimeter of the ORO controlled area did not change from previous years; the level at the "remote" station at Berea, Kentucky, increased slightly. Comparisons are shown in Fig. 2.21, page 7. No significant air contamination problems resulting from Laboratory operations occurred. The increased level at the remote station in Berea, Kentucky, and the occurrence of a similar level of increase in the perimeter area is postulated to have resulted from weapons test fall-out. Background measurements in the Laboratory area averaged 0.12 mr/hr or approximately ten times the value established in 1944; measurements made in the perimeter area averaged 0.02 mr/hr which is less than twice the 1944 value.

Air-borne radioactive particulate matter collected in the Laboratory area during 1958 and averaged on a weekly basis was 2.5×10^{-12} μc/cc compared to 8.2×10^{-12} for 1957. The highest average air contamination level recorded by a single air monitor in the Laboratory area for a given week was 1.2×10^{-11} μc/cc which is a factor of approximately 10^3 lower than the maximum permissible "operating level" of 1×10^{-8} μc/cc. The average air contamination level for the Laboratory area was less than a factor of 2 higher than the level in both the perimeter and remote areas of 1.5×10^{-12} μc/cc. The 1957 levels for the perimeter and remote areas were 1.5×10^{-12} and 9×10^{-13} μc/cc respectively.

The average number of radioactive particles collected by the continuous air monitors (Fig. 2.22, page 8) decreased significantly in all areas from the averages recorded in 1957. The average number of particles per square foot of fall-out surface as shown by gummed paper fall-out trays (Figs. 2.23 and 2.24, pages 9 and 10) decreased significantly in the Laboratory area, decreased slightly in the perimeter area, but increased to a certain extent in the remote area. The decrease in both values in the Laboratory area may be attributed to installation of additional filtration equipment in the off-gas and cell ventilation systems of one of the chemical processing plant. The number of particles detected in the perimeter and the remote areas were of the same order of magnitude as the number in the Laboratory area during most of the year. Such correlation, supplemented by gamma spectrometer analyses and decay studies of numerous filters, points to the predominance of weapons test activity in the general atmosphere. Activity levels determined by rainout measurements in the Laboratory, perimeter, and remote areas (Fig. 2.25, page 11) similarly point to weapons test activity.

The calculated weekly average gross beta concentration in the Clinch River for 1958 was 1.36×10^{-7} μc/cc. As shown in Fig. 2.26, page 12, this is only 17% of the $(MPC)_W$ value based on isotopic distribution determined by radiochemical analyses. The excess occurring during Weeks 27 to 31 is attributed to a leak that developed in an underground waste line. The high level during Week 48 is attributed to highly radioactive silt which had settled behind White Oak Dam. The silt settled out during periods when backwater from Watts Bar Lake submerged the White Oak Creek outlet. The silt subsequently was scoured from White Oak Lake Basin during the first heavy rainfall after Watts Bar Lake was lowered to its winter operating level. The gross beta permissible operating level of 1×10^{-7} μc/cc was exceeded about 35% of the time as shown in Fig. 2.27, page 13.

Preliminary results in the routine program to determine the fission product activity in the water of the Clinch River at Kingston, Tennessee, the nearest population center downstream, show very low radioactivity levels, Table 2.28, page 14. These data were obtained from quarterly analyses of large-volume composites (approximately 20 gal) made up from daily samples taken at Centers

Ferry near the mouth of the Emory River. Additional air monitoring and liquid waste maintenance data are shown in Tables 2.29, 2.30, 2.31, 2.32, and 2.33.

The laundry monitoring unit monitored 265,603 garments for radioactive contamination; about 7%, or 19,754 garments, were contaminated above maximum permissible limits. In addition to the regular routine, 416,058 special items, including towels, shoe covers, gloves, and caps, were monitored.

2.2 Monitoring Details in Tabular and Graphic Form

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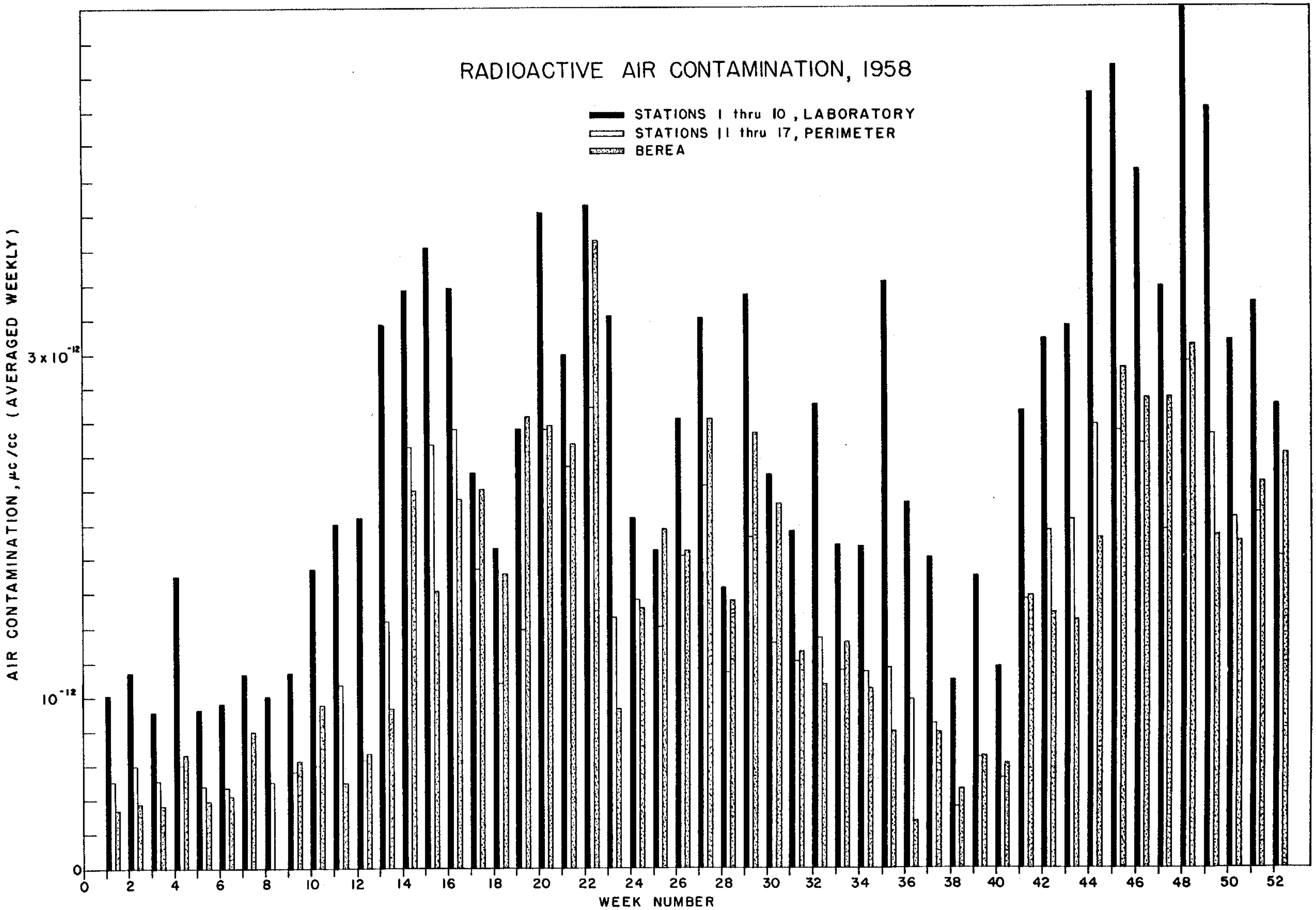

FIG. 2.21 AIR CONTAMINATION LEVELS IN 1958 AS MEASURED ON THE COLLECTING FILTERS OF THF CONTINUOUS AIR MONITORS

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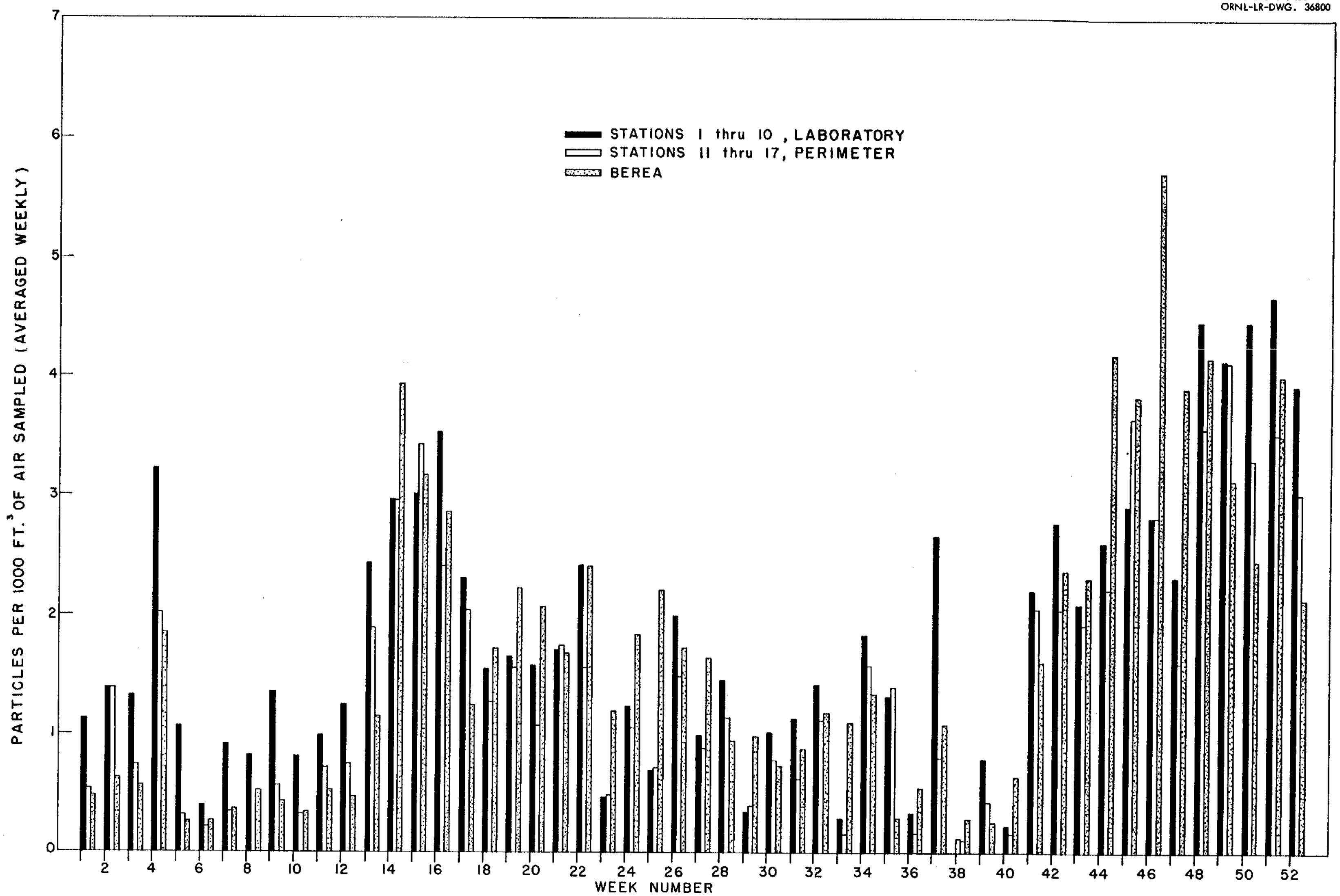

FIG. 2.22 RADIOPARTICULATE FALLOUT COLLECTED ON FILTERS BY CONTINUOUS AIR MONITOR

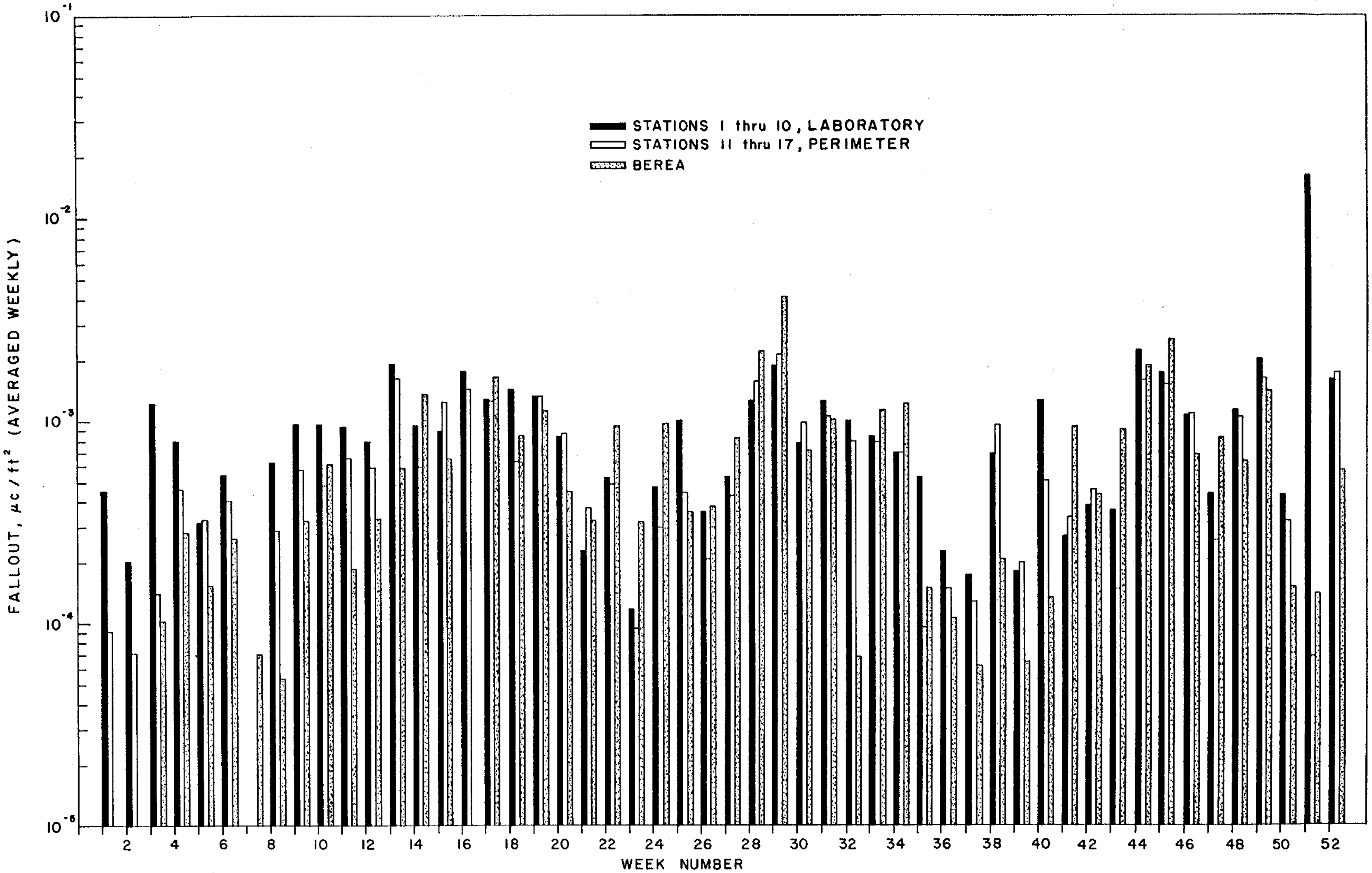

FIG. 2.23 RADIOACTIVE FALLOUT IN 1958 AS MEASURED BY THE GUMMED PAPER METHOD

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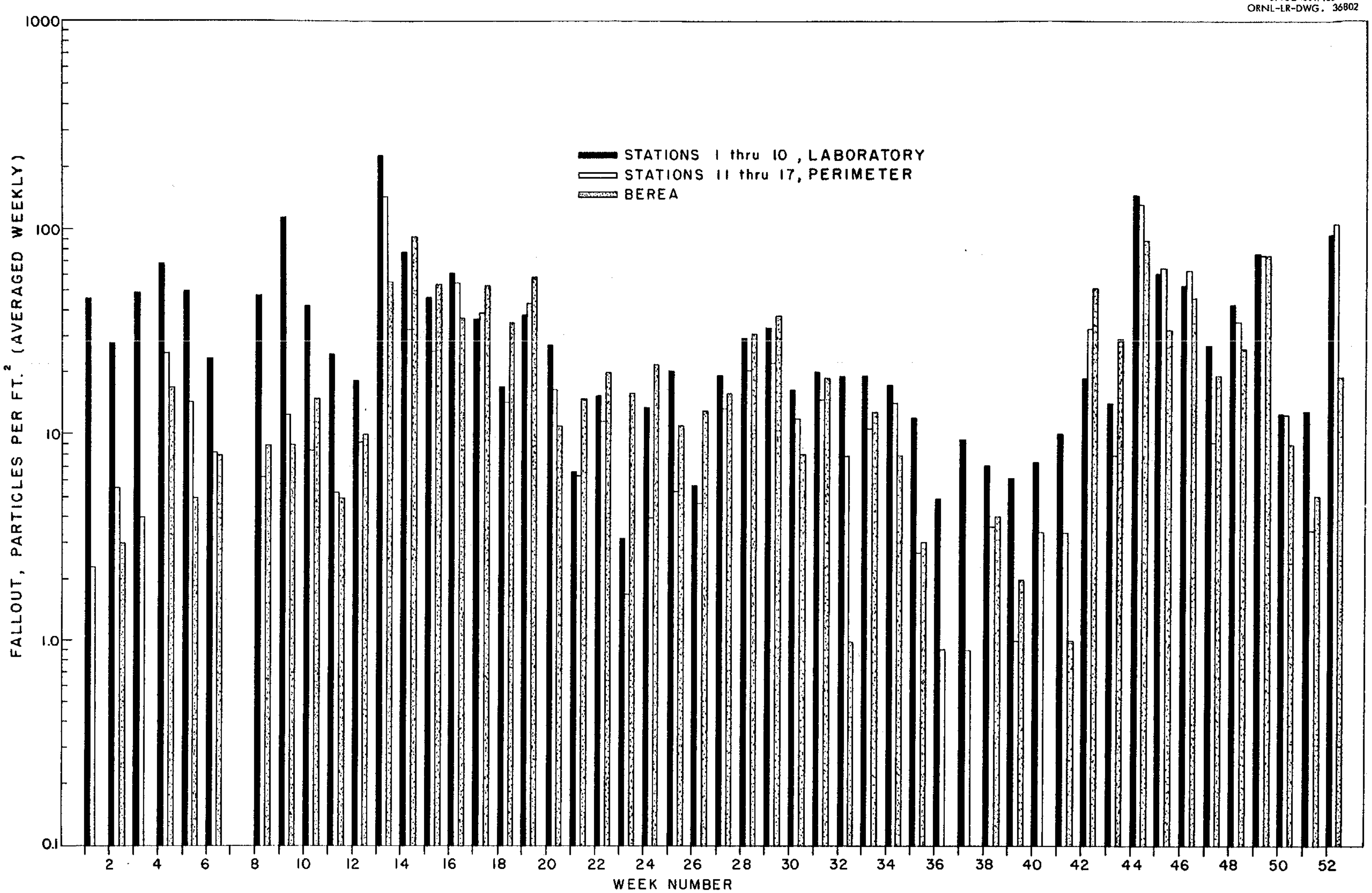

FIG. 2.24 RADIOPARTICULATE FALLOUT IN 1958 AS MEASURED BY GUMMED PAPER METHOD

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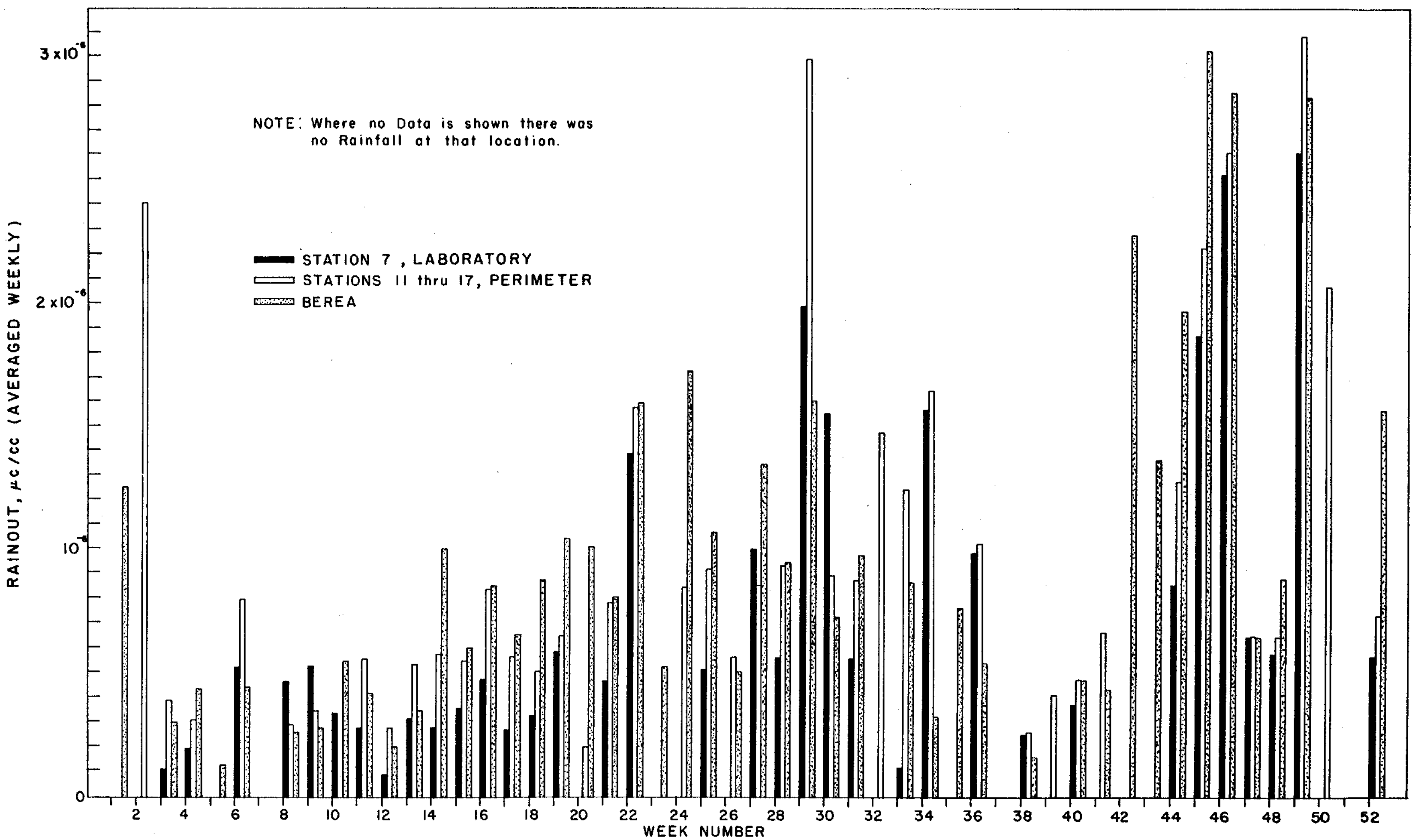

FIG. 2.25 RADIOACTIVITY IN RAIN WATER IN 1958

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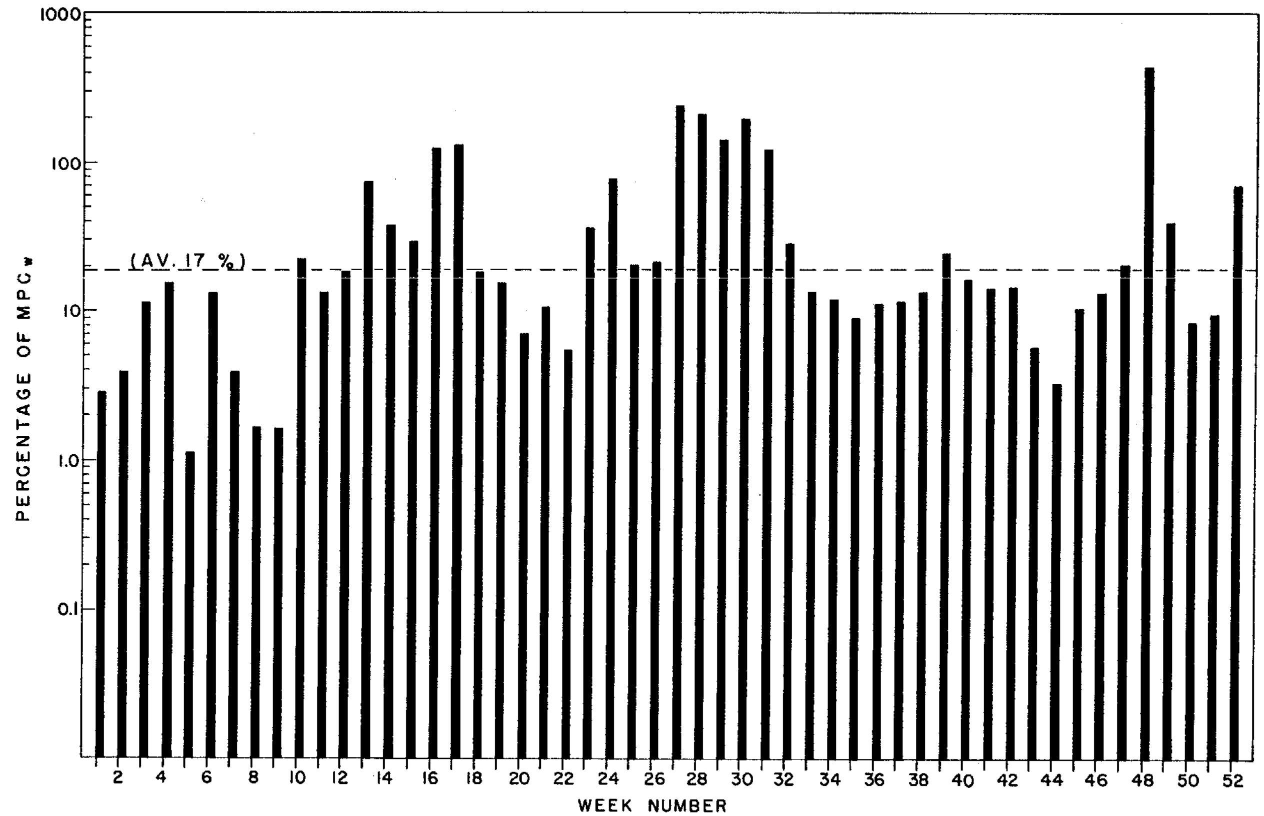

FIG. 2.26 AVERAGE WEEKLY CONCENTRATION OF RADIONUCLIDES IN THE CLINCH RIVER DURING 1958 AS DETERMINED BY RADIOCHEMICAL ANALYSES

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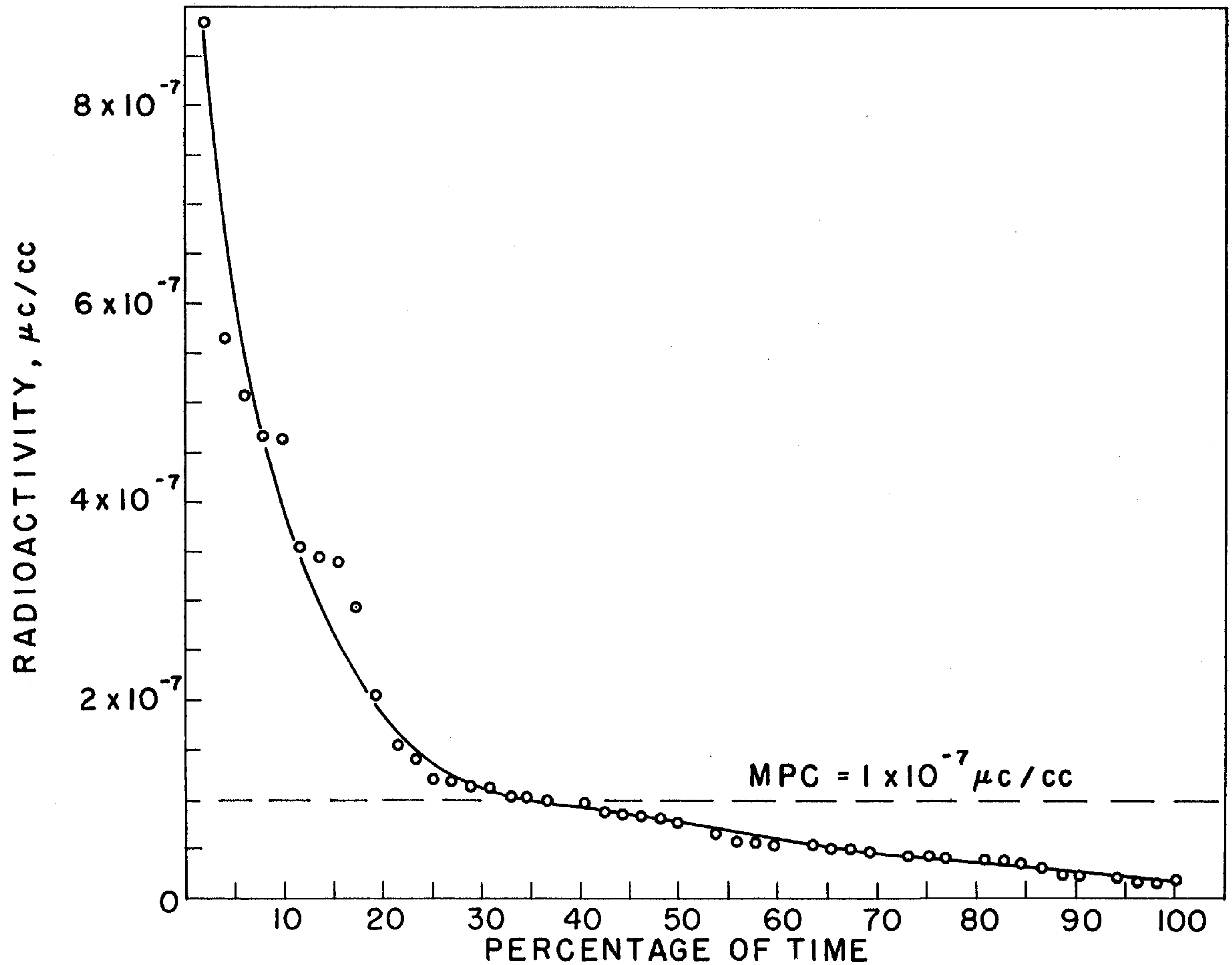

FIG. 2.27 VARIATIONS IN THE CONCENTRATION OF RADIOACTIVITY IN THE CLINCH RIVER, 1958

Table 2.28 Average Fission Product Activity (d/m/ml) in Clinch River Water at Kingston, Tennessee[a], 1958

For 3-month Period Ending	Sr^{90} [b]		Ce^{144} [c]		Cs^{137} [c]		Ru^{106} [c]		$Zr^{95}-Nb^{95}$ [c]		Co^{60} [c]	
	Liquid	Solid	Liquid	Solid	Liquid	Solid	Liquid	Solid	Liquid	Solid	Liquid	Solid
Nov. 27, 1957	~0.08	<0.0004	<0.014	<0.001	~0.003	~0.013	<0.04	<0.004	<0.006	<0.0008	~0.01	~0.003
Feb. 3, 1957	~ .04	<0.0005	<0.012	<0.002	~0.007	~0.014	<0.03	~0.005	<0.004	<0.001	~0.007	~0.003
May 3, 1958	~0.05	<0.0004	<0.017	<0.004	~0.008	~0.013	<0.03	~0.008	<0.005	~0.002	~0.009	~0.004
July 14, 1958	~0.15	<0.001	<0.04	<0.006	~0.01	~0.005	<0.06	~0.005	~0.004	~0.002	~0.009	~0.003
Oct. 23, 1958	~0.069	<0.001	<0.002	<0.002	~0.001	~0.006	~0.003	~0.001	~0.001	~0.002	~0.005	~0.002

[a] Kingston, Tennessee, is the nearest population center downstream from Oak Ridge National Laboratory.

[b] Determined by radiochemical methods.

[c] Determined by gamma spectrometry.

Table 2.29 Average Weekly Air Contamination Data by Stations, 1958

Station No.	Location[a]	Long-lived Activity,[b] μc/cc	No. of Particles by Activity Range[b] $<10^5$ d/24 hr	10^5-10^6 d/24 hr	10^6-10^7 d/24 hr	$>10^7$ d/24 hr	Total	Particles[b] 1000 ft^3
			Laboratory Area					
HP-1	S 3587	22.56×10^{-13}	93.17	4.87	1.92	0.06	100.02	1.86
HP-2	S 3001	24.63	86.56	5.03	1.02	0.13	93.64	1.87
HP-3	S 1000	22.39	89.60	6.10	1.90	0.17	97.77	1.32
HP-4	W 3513	32.78	87.48	5.04	1.58	0.11	94.21	2.14
HP-5	E 2506	40.16	107.04	3.76	1.02	0.10	111.92	2.44
HP-6	SE 3012	21.13	92.50	4.85	1.54	0.21	99.10	1.49
HP-7	W 7001	20.14	95.35	4.17	1.04	0.02	100.58	1.71
HP-8	Rock Quarry	18.95	96.19	3.52	0.96	0.06	100.73	1.72
HP-9	A-10 Site	23.50	104.37	4.46	1.25	0.02	110.10	1.95
HP-10	E 2074	25.25	72.02	3.42	0.96	0.08	76.48	1.83
Average		25.15						1.83
			Perimeter Area					
HP-11	Kerr Hollow Gate	14.63	63.26	2.52	0.82	0.02	66.62	1.31
HP-12	Mid-Way Gate	14.35	66.06	2.65	1.05	0.02	69.78	1.37
HP-13	Gallaher Gate	14.83	67.33	2.73	0.90	0.06	71.02	1.40
HP-14	White Wing Gate	11.20	58.55	2.06	0.51	0.04	61.16	1.20
HP-15	Blair Gate	14.48	69.35	2.57	0.67	0.00	72.59	1.43
HP-16	Turnpike Gate	15.65	82.48	2.30	0.74	0.00	85.52	1.69
HP-17	Hickory Creek Bend	17.35	86.82	2.45	0.51	0.02	89.80	1.76
Average		14.64						1.45
			Remote Area					
B	Berea, Ky.	15.16	83.04	1.92	0.27	0.00	85.23	1.68

a See Maps, Figs. 2.35 and 2.36, Pages 25 and 26.
b Determined by continuous air monitor.

Table 2.30 Average Weekly Fallout Data by Stations, 1958

Station No.	Location[a]	Long-lived Activity,[b] $\mu c/ft^2$	No. of Particles by Activity Range[b] < 10^5 d/24 hr	10^5-10^6 d/24 hr	10^6-10^7 d/24 hr	> 10^7 d/24 hr	Total Particles per sq. ft.
Laboratory Area							
HP-1	S 3587	9.66×10^{-4}	43.78	2.75	1.00	0.10	47.63
HP-2	S 3001	12.87	72.86	3.61	1.66	0.18	78.31
HP-3	S 1000	6.86	25.25	1.39	0.47	0.02	27.13
HP-4	W 3513	7.60	26.84	1.94	0.45	0.06	29.29
HP-5	E 2506	8.75	35.43	1.20	0.31	0.08	37.02
HP-6	SE 3012	39.37	42.98	2.76	1.08	0.16	46.98
HP-7	W 7001	5.73	24.04	1.31	0.49	0.04	25.88
HP-8	Rock Quarry	7.00	20.37	1.29	0.47	0.10	22.23
HP-9	A-10 Site	6.88	20.68	1.55	0.59	0.02	22.84
HP-10	E 2074	8.28	32.21	2.35	1.10	0.04	35.70
Average		11.30					37.30
Perimeter Area							
HP-11	Kerr Hollow Gate	6.21	20.50	1.24	0.40	0.00	22.14
HP-12	Mid-Way Gate	7.87	23.29	1.53	0.69	0.10	25.61
HP-13	Gallaher Gate	6.88	21.59	1.33	0.31	0.04	23.27
HP-14	White Wing Gate	6.61	21.70	1.53	0.33	0.05	23.63
HP-15	Blair Gate	7.57	23.67	1.55	0.45	0.04	25.71
HP-16	Turnpike Gate	6.93	25.10	1.27	0.24	0.02	26.63
HP-17	Hickory Creek Bend	7.08	16.63	1.33	0.65	0.10	18.71
Average		7.02					23.67
Remote Area							
B	Berea, Kentucky	7.15	19.67	1.76	0.57	0.04	22.04

[a] See maps, Fig. 2.35 and 2.36, pages 25 and 26.

[b] Determined from gummed-paper fallout trays.

Table 2.31 Average Weekly Rainout Data by Stations* (1958)

Station Number	Location*	Activity in Collected Rain Water, µc/cc
	Laboratory Area	
HP-7	W 7001	7.28×10^{-7}
	Perimeter Area	
HP-11	Kerr Hollow Gate	9.13×10^{-7}
HP-12	Mid-Way Gate	9.43
HP-13	Gallaher Gate	8.86
HP-14	White Wing Gate	8.80
HP-15	Blair Gate	8.67
HP-16	Turnpike Gate	10.47
HP-17	Hickory Creek Bend	10.90
Average		9.19
	Remote Area	
B	Berea, Kentucky	9.52×10^{-7}

Note: Total rainfall in 1958 was 46.37 in., a deviation of -11.1% from the normal rainfall of 52.17 in.

* See maps, Figs. 2.35 and 2.36, Pages 25 and 26.

Table 2.32 Average Weekly Liquid Waste Discharge, 1958

Measurements	Settling Basin		White Oak Creek Dam	
	Year 1958	% Deviation from 1957 Weekly Average	Year 1958	% Deviation from 1957 Weekly Average
β Curies Discharged	1.76	- 50.6	10.46	+ 37.1
Submersion Data				
β, mrad/hr	0.125	- 42.4	0.055	+ 111.5
γ, mr/hr	0.100	- 41.9	0.028	- 47.4
Total, mrad/hr	0.225	- 42.2	0.083	- 84.4
Pu discharged, μg/cc	406.9×10^{-9}	- 73.8	269.3×10^{-9}	+ 36.5
mg	6.5	- 76.7	23.5	- 48.1

Note: The probable average concentration in the Clinch River below White Oak Creek is calculated to be 1.36×10^{-7} μc/cc, using as a dilution factor the ratio of White Oak Creek discharge to the flow of Clinch River. This is 58.1% greater than the 1957 weekly average.

Table 2.33 Total Samples Processed by the Analytical Units, 1958

	Continuous Air Monitor Filters		Fallout Tray Gummed Papers		Rain Water Samples		Liquid-Effluent Samples			
	Total No.	Weekly Avg.	Total No.	Weekly Avg.	Total No.	Weekly Avg.	Gross β	Total γ Submersion	Pu	Total Preparations for Radiochem.
Local Stations	509	9.7	510	9.8	36	0.7				
Perimeter Stations	377	7.3	370	7.1	62	1.2				
Remote Stations	55	1.1	55	1.1	43	0.8				
Building CAM's	6405	123.2								
Stack Monitors	705	13.5								
Special			338	6.5						
Settling Basin							1089	259	104	12
White Oak Creek							774			
Melton Branch							774			
White Oak Dam							1089	290	103	12
Clinch River										4

2.3 Projects

Local Air Monitoring System - The local air Monitoirng System includes ten stations located directly on, or immediately adjacent to, the Laboratory premises as shown in Fig. 2.34, page 24. Originally, the local air monitor, or LAM, was equipped with a continuous air monitor of the fixed filter type and a scaling unit. The LAM now includes a gummed paper frame and in some cases a rain water collector. The counting rate of the radioactivity collected by filtration is recorded continuously on strip charts at each station and is telemetered via telephone lines to a central recording station at 10-minute intervals. A position manual selector switch permits selection of any given station for continuous observation. The central recording station is equipped with an alarm, which is activated when general air contamination levels become significant; an auxiliary alarm is located at Guard Headquarters for around-the-clock coverage. Installation of a filter-changing mechanism that can be operated from the central recording station is being investigated. A filter changing mechanism operable from headquarters will make it possible to observe immediate changes in the amount of air activity at each station.

Perimeter Air Monitoring System - The Perimeter Air Monitoring System established in 1956 consists of seven stations located about the perimeter of the AEC-controlled area as shown in Fig. 2.35, page 25. The Perimeter Air Monitor, or PAM, is similar to the LAM except that measurements are not recorded continuously. The addition of radiation detector units and telemetering equipment is being contemplated. However, at the present time, these stations collect air samples which are processed weekly in the Laboratory.

Remote Air Monitoring System - Only one remote station has been in operation for some time, and it is located at Berea, Kentucky. However, construction has started on the Remote Air Monitor, or RAM, to be located at six TVA dam sites and at the Dale Hollow Dam, a dam operated by the U. S. Corps of Engineers. The RAM's will practically encircle the Oak Ridge Area, as can be seen in Fig. 2.36, page 26 at distances of 20 to 75 miles. They will assist in establishing background conditions and in determining the origin of air contamination and fall out. All of the RAM station shelters have been completed. Stations at Norris and Loudon Dams, installed in December of 1958, are equipped with air-sampling equipment, gummed paper frames, and rain water collecting equipment. The remaining five stations will be installed in 1959. Although eventually the same type of equipment will be used in both the PAM and RAM systems, no telemetering will be included from the RAM stations as these stations are attended around-the-clock by TVA and U. S. Corps of Engineers personnel and data can be relayed by telephone.

Proportional Sampler at White Oak Dam - A proportional sampler for large-volume liquid flows has been designed, installed, and tested at the White Oak Creek Dam. The basic unit, Fig. 2.37, page 27, consists of a circulating pump and a collecting vessel in which the volume of water is controlled by an overflow pipe which in turn varies in height in proportion to the head of the stream. Associated piping, solenoid valves, and phase timers complete the system. The sampling interval is normally 10 minutes but can be adjusted by regulating the timing mechanism. This approach to proportional sampling overcomes difficulties associated with other types of samplers in that it is adaptable to wide variations in stream head, requires little maintenance, and is less susceptible to clogging resulting from debris, incrustation, and algae formations.

Automatic Controls at White Oak Creek Dam - A gamma monitor installed at White Oak Dam consists of a scintillation counter submerged in a portion of the effluent circulated from White Oak Creek. Counting rate data are telemetered to, and recorded at, central headquarters. Excessive concentration of radioactivity in the effluent causes an immediate alarm at headquarters.

Aerial Surveys - A 125-hp light aircraft, Fig. 2.38, page 28, is being used to make aerial survey flights in the general vicinity of the Laboratory. The general flight pattern is shown in Fig. 2.39, page 29. The advantages of aerial surveys are described in AERE-R-2890.

An ORNL Model Q-1105 Scintillation Survey Meter is used in the aerial survey program. The instrument, modified to drive a 1-mv chart recorder, utilizes a 2 x 2 in. sodium iodide crystal. The meter has four ranges, viz., 3K, 10K, 30K, and 100K. The full scale sensitivity for gamma radiation is about 0.05, 0.15, 0.50, and 1.5 mr/hr, respectively; the time-constant is of the order of 1 sec or less; the meter reading is recorded on the chart recorder.

A typical chart recording, Fig. 2.40, page 30, of the background profile encountered on a flight directly over the Laboratory shows a slight increase in the radioactive background as the Laboratory is approached from the east; significant peaks are observed over the 7000 area, the Activation Analysis Facility, the stack area of the Laboratory proper, and an abandoned burial ground. Steady background levels are observed after leaving the burial ground area. The generally higher level of activity encountered upon approaching the Laboratory was postulated to be the result of stack-emitted activity, as a steady wind blew to the east at the time of the flight. The peak in the 7000 area was attributed to a radiographic testing facility and the peak at the Activation Analysis Facility to a high-level radioactive source being used for experimental work. The peak at the burial ground represents above-ground storage of contaminated materials and equipment.

The results of a study on detection and measurement of I^{131} as an air-deposited contaminant on pasture grasses indicated that 1 $\mu c/m^2$ of iodine can be detected with portable scintillation equipment in light aircraft. Reports of the Windscale incident indicate that the maximum permissible concentration of I^{131} in whole milk was 0.1 μc per liter of milk and that the corresponding contamination levels of pasture land on which the cows grazed was 1.0 $\mu c/m^2$. To simulate conditions postulated in the Windscale data, 320 μc of I^{131} in an aqueous solution of 72 ml was prepared. The iodine solution was contained in 36 polyethylene bottles of 1 ounce capacity with 2 ml of solution in each bottle, which gave roughly 8.85 μc per bottle. The bottles were placed on the ground at 100-ft intervals on a 500 x 500 ft grid, equivalent to 1.4 $\mu c/m^2$, and were readily detected at altitudes up to 500 ft. For detection of lower levels of contamination, the ORNL Instrumentation and Controls Division is designing an improved instrument which will include shielding of the detector unit to reduce the background reading.

River Survey - Annual surveys have been made of the Clinch and Tennessee Rivers since 1951 in order to evaluate the radioactivity in the bottom sediment in terms of potential, present, and future hazard to humans. The River Survey Program is described in detail in ORNL-2847.

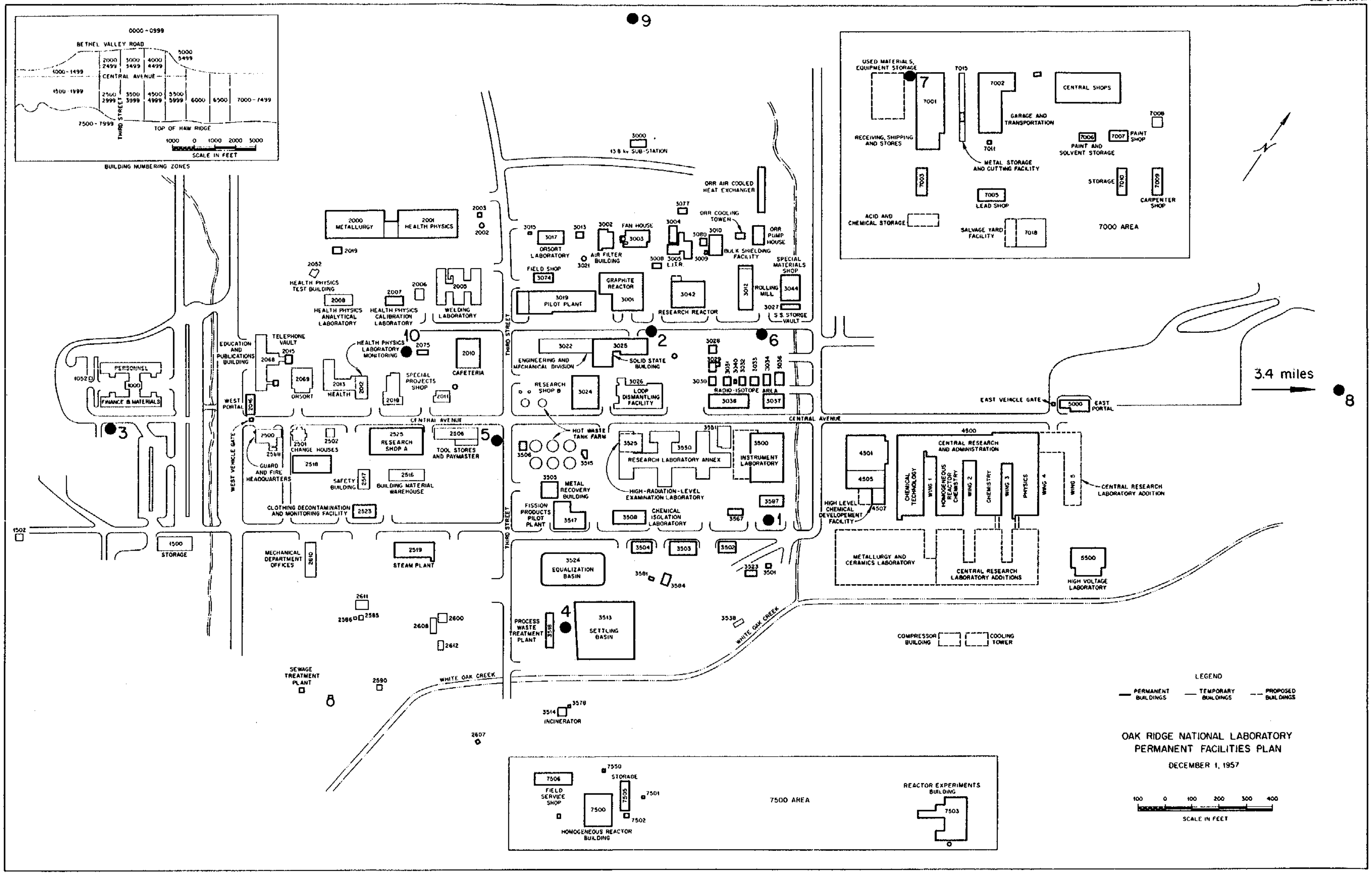

Fig. 2.34. Map of the Laboratory Area Showing Locations (●) of the Local Air-Monitoring Stations.

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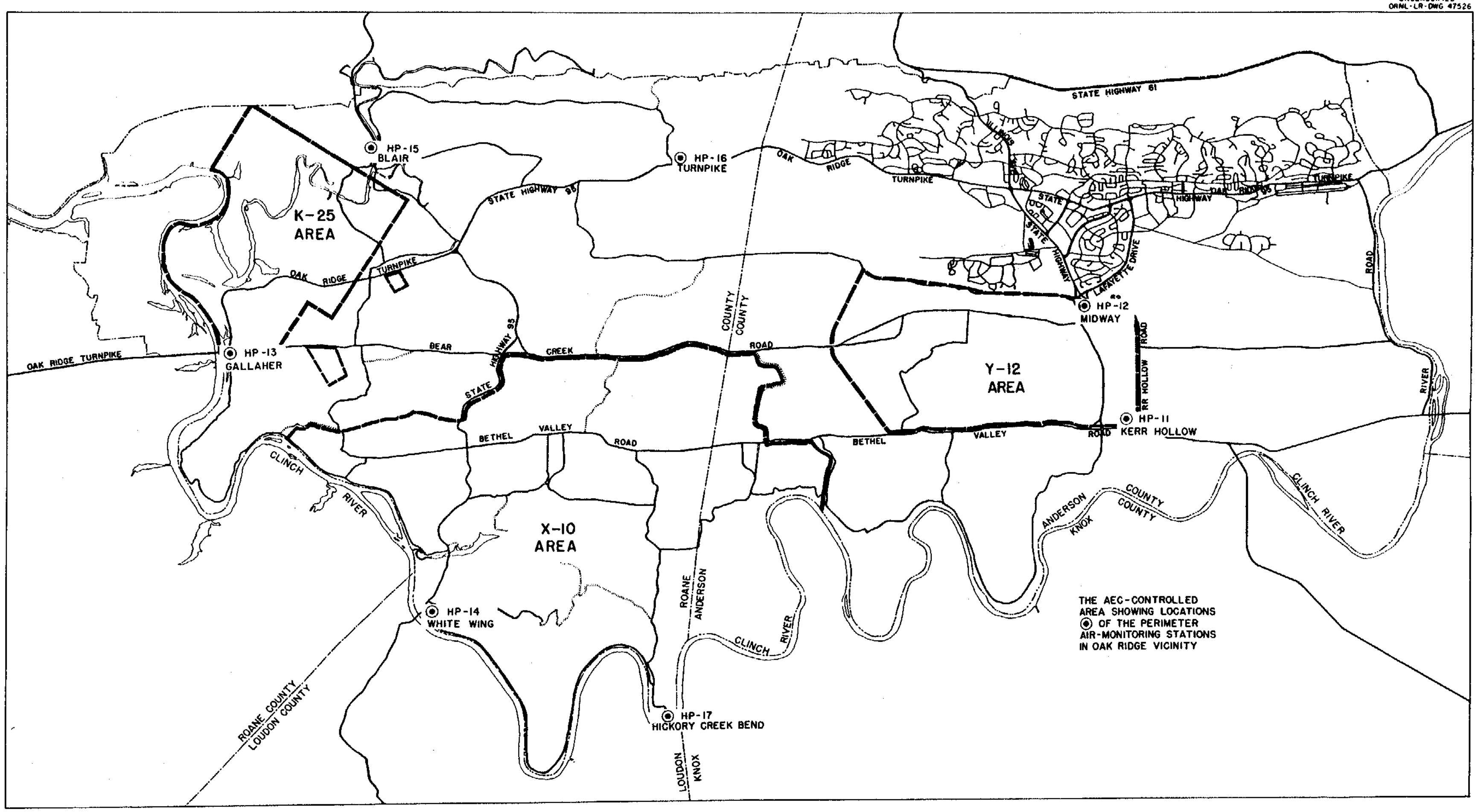

Fig. 2.35. The AEC-Controlled Area Showing Locations (•) of the Perimeter Air-Monitoring Stations in the Oak Ridge Vicinity.

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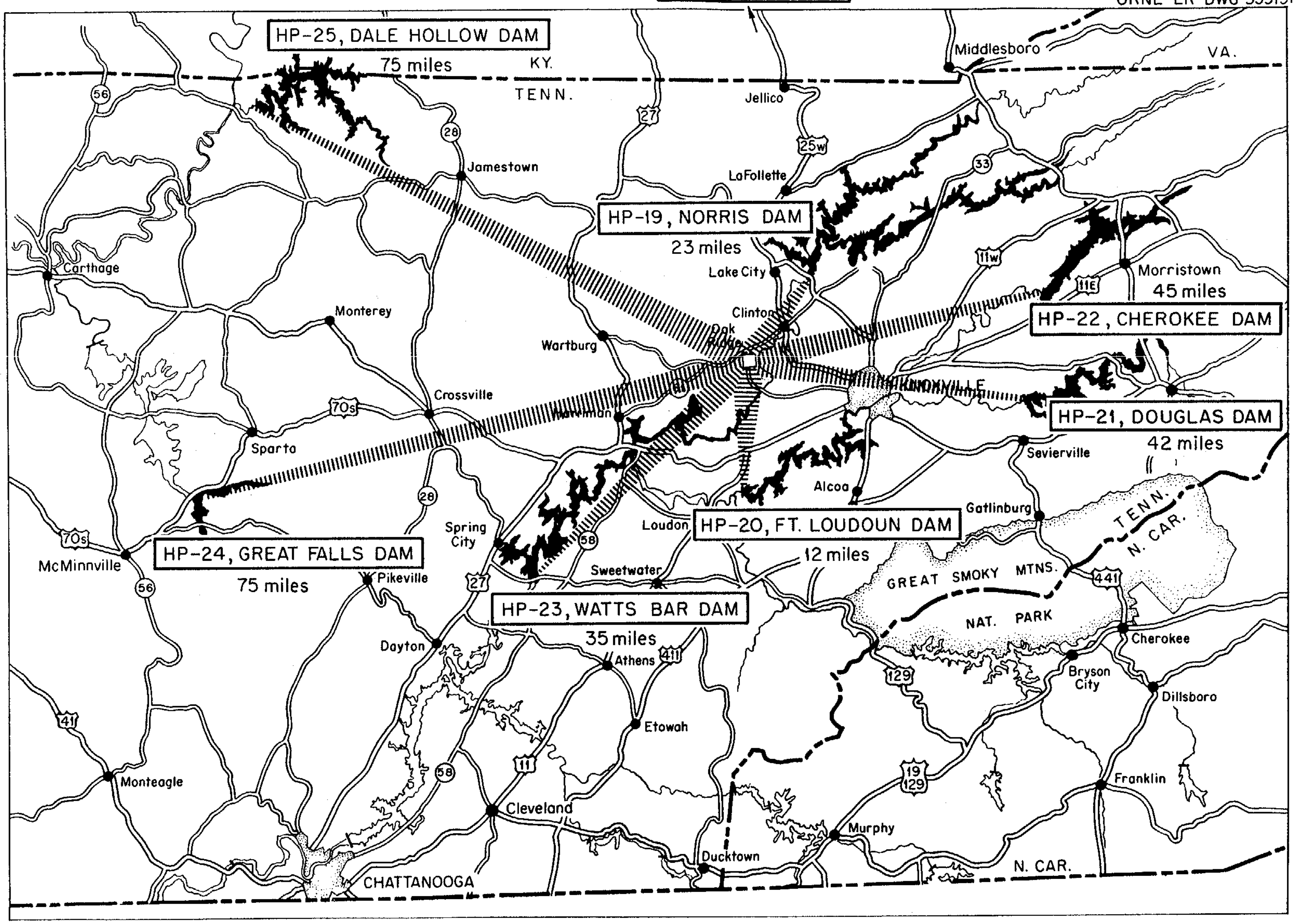

Fig. 2.36. Map of the East Tennessee Area Showing Locations of the TVA and U.S. Corps of Eng. (Dale Hollow) Dams. A monitoring station is located at each dam site.

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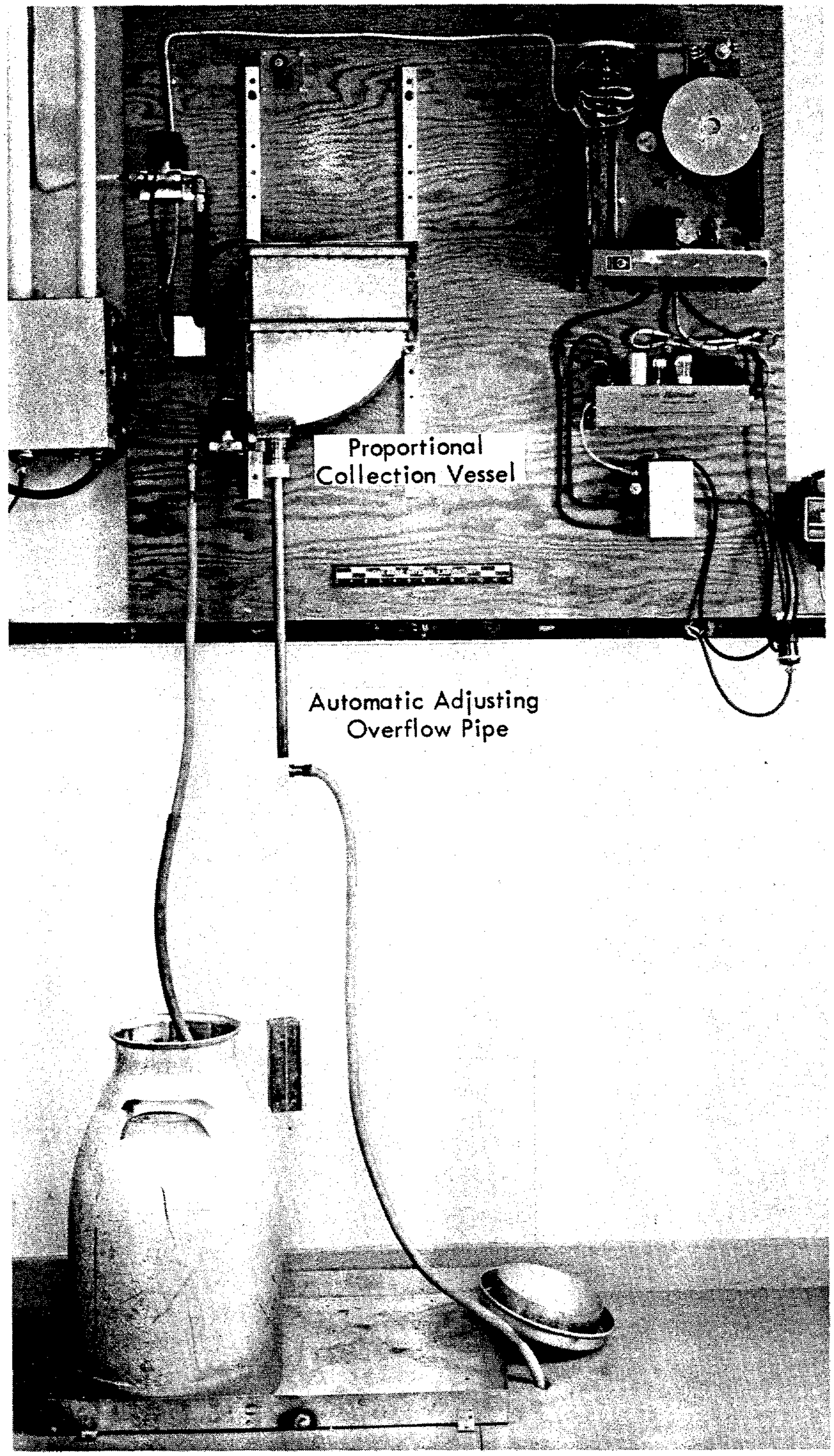

Fig. 2.37. Continuous-Flow, Proportional-Volume Liquid Sampler.

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Fig. 2.38. Light Aircraft Used for Routine Aerial Surveys.

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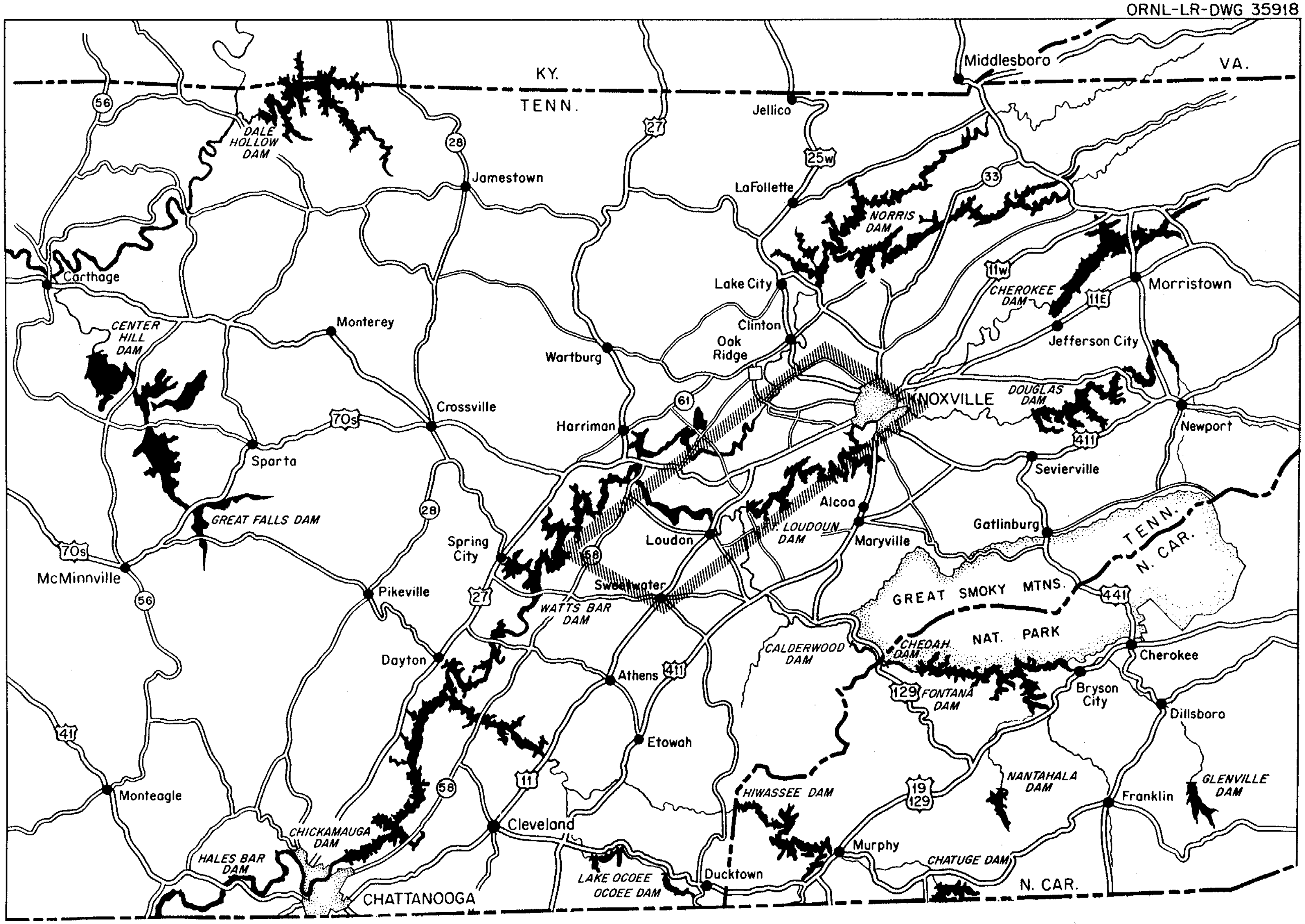

Fig. 2.39. Map of East Tennessee Area Showing the Flight Pattern Followed in a Routine Aerial Survey. The flight starts from the Island Airport, Knoxville.

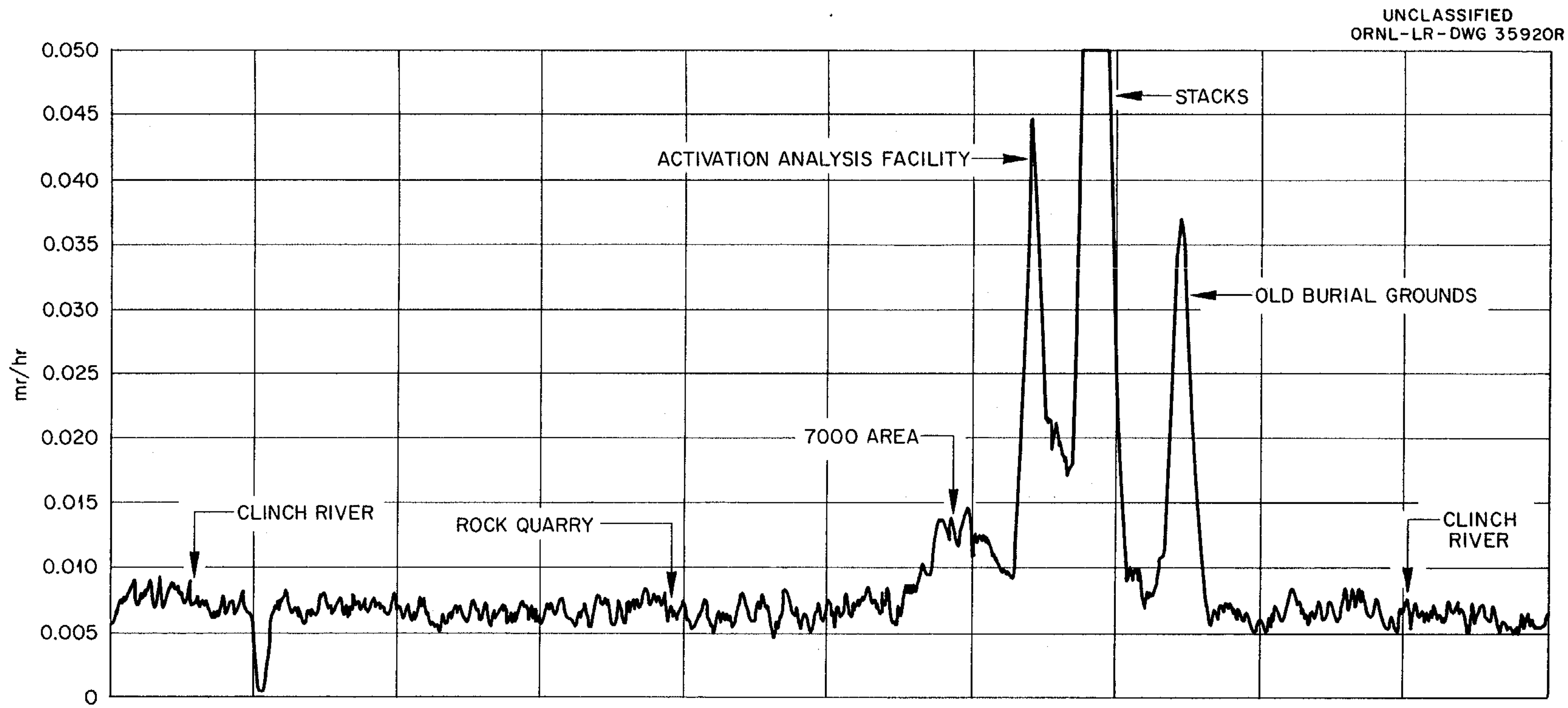

Fig. 2.40. Typical Chart Recording for a Routine Aerial Survey Flight Over Oak Ridge National Laboratory.

3.0 Personnel Monitoring

J. C. Ledbetter B. T. Walters

3.1 Personnel Exposure Summary

There were no personnel exposures during 1958 as recorded on the personnel meters or from bio-assay analyses, which exceeded the limits recommended in NBS Handbooks 52 and 59. The highest total dose sustained by a Laboratory employee was 55% of the maximum permissible exposure of 15 rem/yr. The ten employees sustaining the highest exposures during the year averaged 6.0 rem each. The average yearly exposure for all Laboratory personnel was 0.43 rem. The ten individuals who received the highest exposures in 1958 were employed as follows:

Dept. or Div.	No. Employees
Insp. Engr.*	1
Anal. Chem.	1
Radioisotopes Prod.	8

As of December 31, 1958, the exposure record for the ten Laboratory employees who have sustained the highest cumulative dose of penetrating radiation is shown in Table 3.21, page 33. The exposure record for the ten Laboratory employees who have sustained the highest exposure based on the age formula, 5(N-18), is shown in Table 3.22, page 33.

As shown in Table 3.23, page 34, the total number of pocket meters distributed in 1958 was 259,462 of which only 194 were non-readable. The total number of films issued was 118,777.

As shown in Table 3.24, page 35, no employee received a dose greater than 12 rem of penetrating radiation. Only one employee has accumulated a total dose which exceeds the age proration formulas, Table 3.25, page 35.

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* Exposure occurred while employee was assigned to the Chemical Technology Division.

3.2 Statistics

Table 3.21 Pertinent Data Regarding the Ten Laboratory Employees Who Have Sustained the Highest Cumulative Dose of Penetrating Radiation as of December 31, 1958

Employee	Department or Division	Age (yrs)	Tenure of Employment (yrs)	Dose (rem)
A	Research Shops	24	2	67.0*
B	Radioisotope Prod.	39	14	64.8
C	Radioisotope Prod.	34	15	58.8
D	Radioisotope Prod.	40	11	58.4
E	Radioisotope Prod.	52	14	56.1
F	Radioisotope Prod.	51	13	52.8
G	Radioisotope Prod.	33	12	50.2
H	Radioisotope Prod.	31	8	46.5
I	Radioisotope Prod.	39	7	46.0
J	Radioisotope Prod.	27	7	42.5

* This exposure resulted from an accident in 1957 involving the Chem Tech Division.

Table 3.22 Pertinent Data Regarding the Ten Laboratory Employees Who Have Sustained the Highest Exposure as Based on the Age Formula 5(N-18). (Note: Employees A, B, C, D, H, and J are also listed in Table 3.21.)

Employee	Department or Division	Age (yrs)	Tenure of Employment (yrs)	% MPE 5(N-18)
A	Research Shops	24	2	223*
J	Radioisotope Prod.	27	7	95
C	Radioisotope Prod.	34	15	74
K	Radioisotope Prod.	28	9	71
H	Radioisotope Prod.	31	8	71
L	Instr. and Controls	28	7	69
G	Radioisotope Prod.	33	12	67
B	Radioisotope Prod.	39	14	62
M	Radioisotope Prod.	30	6	58
N	Radioisotope Prod.	20	1	56

* This exposure resulted from an accident in 1957 involving the Chem Tech Division.

Table 3.23 Personnel Meter Distribution and Performance Data

1.	Pocket Meters	
a.	Meters Distributed	259,462
b.	Readable Meters	259,268
c.	Non-readable Meters (damaged or lost)	194
d.	Non-readable Pairs	1
e.	Off-scale Readings	1,051
f.	Off-scale Pairs	52
2.	Film Meters	
a.	Distribution and Processing Data	
1)	Film Badge Meters, routine (13-week cycle)	24,428
2)	Film Badge Meters, non-routine	3,904
3)	Film Meters, Paper (disposable type)	36,656
4)	Rings, Packets, etc.	8,213
5)	Neutron Film, routine (13-wk. cycle)	34,433
6)	Neutron Film special	1,844
7)	Other Installations or Agencies	5,508
8)	Calibrations	3,791
9)	Total Films Handled	118,777
b.	Reasons for Non-routine Processes (processes other than quarterly change)	
1)	Special Request	175
2)	Security (Name change, etc.)	12
3)	Pocket Meter Total $>$ 1500 mr	11
4)	Off-scale Meters (pocket meters)	63
5)	Total	261

Table 3.24 Dose Data Summary for Laboratory Population Involving Exposure to Penetrating Radiation During 1958

Dose Range (rem)	Number of Employees	Percentage of Population
1 or less	4082	91.2
2 or less	4348	97.1
3 or less	4425	98.9
4 or less	4449	99.4
5 or less	4464	99.7
6 or less	4470	99.9
7 or less	4474	99.98
8 or less	4474	99.98
8.3 or less	4475	100.00

Table 3.25 Dose Data Summary for Laboratory Population as of Dec. 31, 1958, Involving Cumulative Exposure to Penetrating Radiation as Based on the Age Formula 5(N-18)

Dose Range % 5(N-18)	Number of Employees	Percentage of Population
10 or less	4225	94.4
20 or less	4368	97.6
30 or less	4433	99.1
40 or less	4457	99.5
50 or less	4464	99.7
60 or less	4467	99.8
70 or less	4470	99.9
80 or less	4473	99.95
90 or less	4474	99.98
100 or less	4474	99.98
>100	1	0.02

3.3 Projects

Badge-Meter - Multi-purpose badge-meters for monitoring and security applications were developed and put into service. The badge-meter, Fig. 3.31, page 37, includes two film packs for routine day-to-day monitoring and is provided with a system of elemental foils which, when complemented by the Hurst Threshold Detector[1], enables the measurement of an accidental high level neutron and gamma exposure.

Neutron Monitoring Film - Long-term statistical analyses indicate that Kodak "personnel monitoring" film Type A is preferable to Type B-2 in a monitoring system such as the ORNL monitoring system. The use of Type A over Type B-2 is based on the following:

(1) The gamma film in the Type B-2 packet contributes to track fading in the neutron-sensitive emulsion.

(2) There was a recorded increase in the number of cases of light leaks with Type B-2. (The Type B-2 packet is thick and bulky, giving rise to breaks in the wrapper.)

(3) Although greater accuracy is possible with the use of Type B-2, the difference, in practice, is not significant and is on the "safe side". With Type A the dose is slightly overestimated for neutron energies over 5 mev. The two types of film are compared in Table 3.31, page 38.

(4) The Type A packet can be purchased for about 20% of the price of the Type B-2 packet.

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[1] G. S. Hurst, et al., "Techniques of Measuring Neutron Spectra with Threshold Detectors--Tissue Dose Determination", Rev. Sci. Instr. 27, 153-156 (1956).

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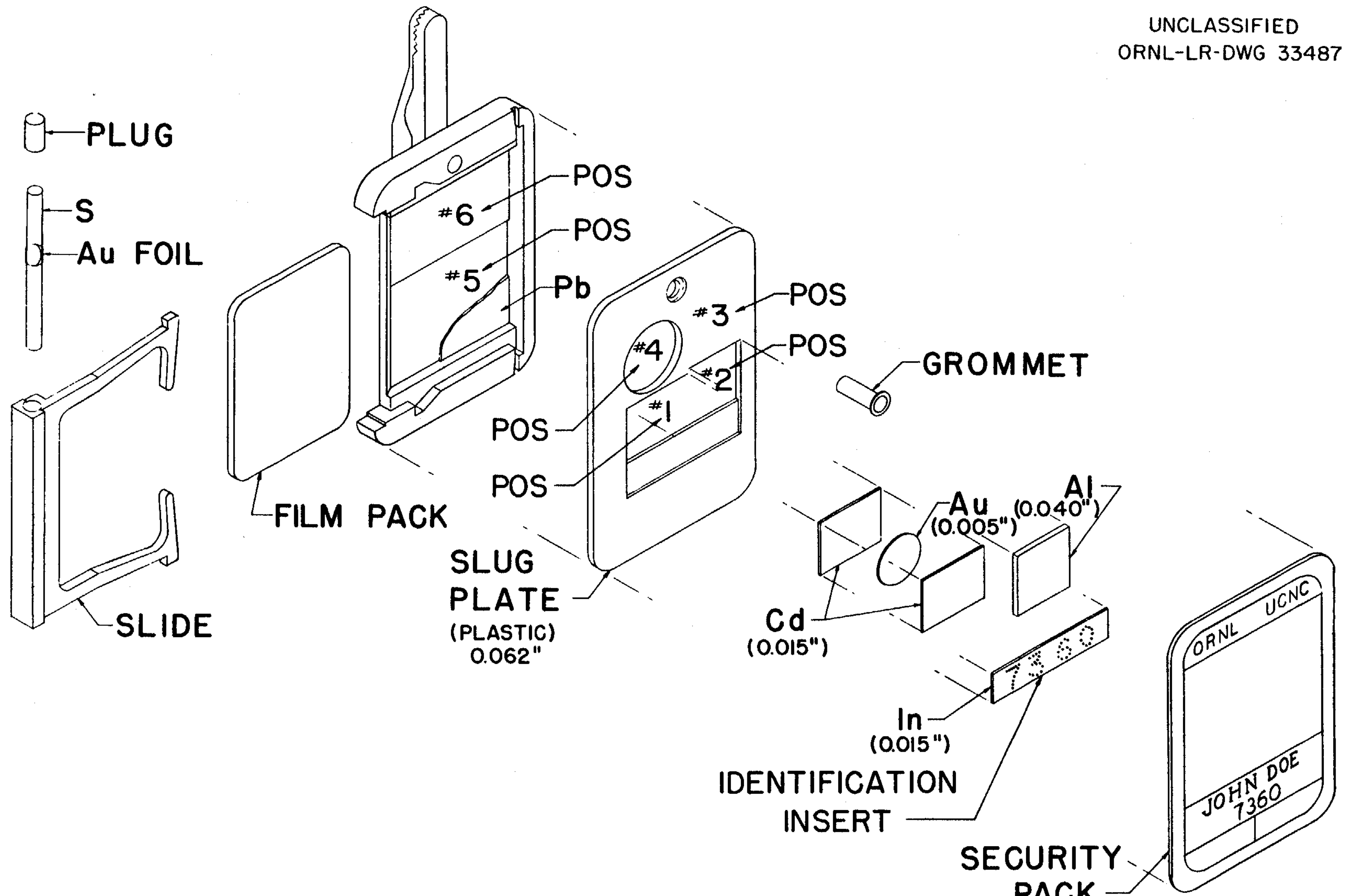

Fig. 3.31. Multi-Purpose Badge Meter for Monitoring and Security Application.

Table 3.31 Comparison of Two Types of Nuclear Track Films (1958)

Mev	$n/cm^2/rem$	RBE	Relative Number of Tracks[a]	
			Type B-2	Type A
1.0	2.6×10^7	10.5	100[b]	100
2.5	2.9×10^7	8	140	133
5.0	2.6×10^7	7	208	206
7.5	2.4×10^7	7	220	275
10.0	2.4×10^7	6.5	240[c]	330[d]

[a] Data derived from curves in the paper, "A Neutron Film Dosimeter", J. S. Cheka, Nucleonics, Vol. 12, No. 6, p. 40 (1954).

[b] Maximum reading ~ 30 rem.

[c] Maximum reading ~ 12.5 rem.

[d] Maximum reading ~ 9 rem.

4.0 Assays and Instruments

E. D. Gupton P. E. Brown

4.1 Summary

A total of 342,946 samples were processed by the Counting Facility for an average of approximately 6,600 samples per week. The total number of samples processed in the Bio-Assay Laboratory was 5,095, or approximately 100 samples per week. The samples submitted by Laboratory personnel for analysis represented more than 95% of the total number of samples requested for analysis.

Approximately 3,700 instruments were repaired, adjusted, and calibrated. The Cutie Pie required more frequent servicing than other instruments. Each Cutie Pie was serviced an average of 6.3 times.

Instruments requisitioned and/or procured this year amounted to approximately $112,471.

4.2 Service Functions Detailed

Table 4.21 Counting Services, 1958

Type of Sample	Alpha	Beta	Gamma	Total	Average No. per Week
Smears	136,910	147,010		283,920	5,460
Air	22,554	22,311		44,865	863
Decay and absorption studies	108	3,798		3,906	75
Thyroid counts			50	50	1
Nasal smears		8		8	
Neutron threshold foil counts			300	300	6
Standards				9,333	180
Other				500	10
Total				342,946	6,595

Table 4.22 Bio-Assays, 1958

Determinations for this period	Samples Requested	Samples Received	Samples Weekly Average	Highest Specimen Analyzed
U	1428	1203	23.1	1400 d/m/24 hr. Spec.
Sr	1684	1452	27.9	165,000 d/m/24 hr. Spec.
Gross α(Pu, Th, Am, Cm), urine	1148	966	18.2	3.6 d/m/24 hr. Spec.
Gross α(Th), feces	1055	890	17.1	990 d/m/24 hr. Spec.
Ra	244	189	3.6	11 d/m/24 hr. Spec
Po	1	21		41 d/m/24 hr. Spec.
Gross β	160	134	2.6	80,000 d/m/24 hr. Spec.
Pa	37	31	0.6	315 d/m/24 hr. Spec.
H^3	21	21	0.4	4 μc/liter of urine
Pb, blood	59	59	1.1	0.26 mg/100 g of blood
Pb, urine	150	150	2.9	0.29 mg/liter of urine

Table 4.23 Counting Facilities, 1958

Type	Counting Room, Bldg. 3550 In Service	Counting Room, Bldg. 3550 Received This Period	Bio-Assay Lab In Service	Bio-Assay Lab Received This Period
GM, end window	14	8(replacement)	4	3(replacement)
GM, side window	2	1(replacement)		
Alpha scintillation	6	3(addition)	10	1(addition)
Gamma scintillation	2	0	2	1(addition)
Proportional	7	0	1	0

Table 4.24 Calibration Services, 1958

Type	Total Services	Average Calibration per Instrument
	Portable Instruments	
Cutie Pie	1,856	6.3
Juno	112	3.5
Samson	200	4.8
GMSM	977	5.7
Dosimeter	378	1.2
PSA	49	4.4
Miscellaneous	146	3.3
	Miscellaneous Calibrations	
Film	1,431	
Monitrons	214	
Medical Survey	256	
Minometers	7	
Other	35	

Table 4.25 Assignment to Field Areas, 1958

Type	Bldg. 2008	Counting Room	Bldg. 3001	Bldg. 3019	Bldg. 3026	Bldg. 3038	Bldg. 3505	Bldg. 3550	Bldg. 4500	Bldg. 7500	Bldg. 3517	Y-12	Total
					Portable Instruments								
Cutie Pie			57	28	19	40	12	27	60	23	14	14	294
Juno			8	1	3	1	0	2	11	2	0	4	32
Samson			0	5	0	0	4	6	13	0	0	14	42
GMSM			29	11	9	20	4	23	43	9	5	18	171
Dosimeter			26	45	22	33	55	30	47	6	20	25	309
PSA			1	1	1	1	0	1	4	1	0	1	11
Misc.			15	1	1	6	1	1	7	5	2	5	44
					Counting Equipment								
GM, End Window	2	14	2	1	0	1	0	1	2	0	1	2	26
Alpha scintillation	9	6	2	1	0	1	0	0	0	0	1	3	23
Proportional	0	7	0	0	0	0	0	0	4	0	0	1	12

Table 4.26 Calibration Film Supplied to Personnel Monitoring (1958)

Dose(mrem)	Type Film	Number of Films
500	DuPont 552	946
1,000	DuPont 552	946
2,000	DuPont 552	946
5,000	DuPont 552	946
10,000	DuPont 552	946
20,000	DuPont 552	946
30,000	DuPont 552	130
50,000	DuPont 552	130
75,000	DuPont 552	130
100,000	DuPont 552	130
1,000	Eastman NTA	8

Table 4.27 Material Supplied in Emergency Kits (1958)

Instruments	Clothing and Other Equipment
	Portable Kits (total 4)
Radicond	Red wax pencil
Cutie Pie	Write-on tape
GMSM/earphones	Writing pad and pencil
DAS	Plastic shoe covers
Dosimeters	Plastic bags
Charge box	Respirators
	Extra batteries
	Perimeter Station Kits (total 3*)
Cutie Pie, 50 r/hr	Flashlight batteries
GMSM	Write-on tape
Spare GM tube	Radiation hazard tags
Juno	Box of film
Dosimeters, 50 r(2)	Paper clips
Charging unit	Pencil and paper
Film badges (2)	Wax pencil
Respirator	Leather gloves (3 pr.)
	Overshoes (3 pr.)
	Coveralls (3 pr.)
	Raincoats (3)
	Hard hat
	First aid kit
	Pocket knife

* Stations at White Wing and Gallaher gates and in calibrations truck

Table 4.28 Instruments Requisitioned and/or Received (1958)

Type	Model	Quantity	Unit Cost	Total Cost	Status
Beta counter	Q 1743-Spec.	2	$1400	$2800	In service
Scalers	Q 1743A	4	700	2800	In service
Power supplies	Reg. Hi-Voltage	4	400	1600	In service
Timer	4-scaler	2	500	1000	In service
LAM rate meter	Q 1554B	1	950	950	In service
LAM rate meter	Q 1554B	1	950	950	On order
Background Monitor	Q 1957	2	1200	2400	In service
Count rate meter	Victoreen 743	4	400	1600	In service
Count rate meter	Atomic 410	4	400	1600	In service
Scint. Flounder	ORNL	1	2000	2000	In service

4.3 Projects

ORNL Whole Body Counter - Structural and equipment design work on an ORNL Whole Body Counter facility is nearing completion. A large portion of the construction work, involving modifications to Building 2008, is completed. A 200-channel analyzer and one 9 x 4 in. cyrstal are on order. Other items of equipment will be requisitioned when design is complete and necessary funds have been approved.

Low Level Alpha Air Monitor - Experiments conducted in April, 1956, demonstrated the feasibility of an air sampling device which would detect relatively low levels of air-borne alpha emitters in the presence of radon and its daughters. Earlier experiments indicate that the ratio of the beta particles to alpha particles emitted per unit time from an air sample containing radon daughters is constant, even though the concentration of radon in the air is variable. The system is illustrated by block diagram in Fig. 4.31, page 49. An experimental unit is shown in Fig. 4.32, page 50. Field testing of this experimental unit is completed, with satisfactory results except when the detectors are located where there is widely variable non air-borne gamma radiation.

River Survey Instrument - During the 1958 river survey a scintillation counter, built by the Instruments and Controls Division, was demonstrated to be suitable for use as a river survey instrument after some modifications. The unit includes a 2 x 1-3/4 in. Na I crystal and a 2 in., 14-stage photomultiplier tube connected to a battery-powered scaler. Temperature sensitivity, energy dependence, battery life, and stability tests are yet to be determined.

Modernization of Survey Monitoring Instruments - A program to develop and/or purchase the best available instruments required for survey and monitoring applications continues. Developments and purchases during 1958 included the following:

a. Portable alpha scintillation counter, developed by the Design Section of the Instruments and Controls Division, Fig. 4.33, page 51, a versatile, transistorized device for alpha hazard detection and analysis. One prototype has been tested; four additional instruments are on order.

b. GM type background monitor, Q-1961, developed by the Design Section of the Instruments and Controls Division, a reliable, low-level background monitor. Two of these are in service.

c. Scintillation alpha monitor, Q-1957, developed by the Design Section of the Instruments and Controls Division, a reliable a-c operated, poppy rate meter for alpha hazard detection and analysis. Five have been fabricated and placed in service.

d. Automatic air sampler, utilizing a moving tape, designed by the Instruments Group of the Applied Health Physics Section. Two β-γ types, Fig. 4.34, page 52, and five α types have been fabricated and placed in service.

Instrument Test and Evaluation Program - A joint effort with the Instruments and Controls Division continues in the testing and evaluation of instruments. This, in part, includes perusal of technical reports and commercial literature relating to radiation survey and monitoring instruments. As a result, the following items have been received on loan or purchased for testing:

(1) portable gas-flow alpha proportional counter, Eberline model PAC-3G;

(2) GM scaler, Baird-Atomic "Abacus";

(3) combination scaler-rate meter, Nucleonic Corporation of America model RCR-2;

(4) portable gamma rate meter, Civil Defense type, Victoreen model 710B;

(5) area background monitor, Victoreen.

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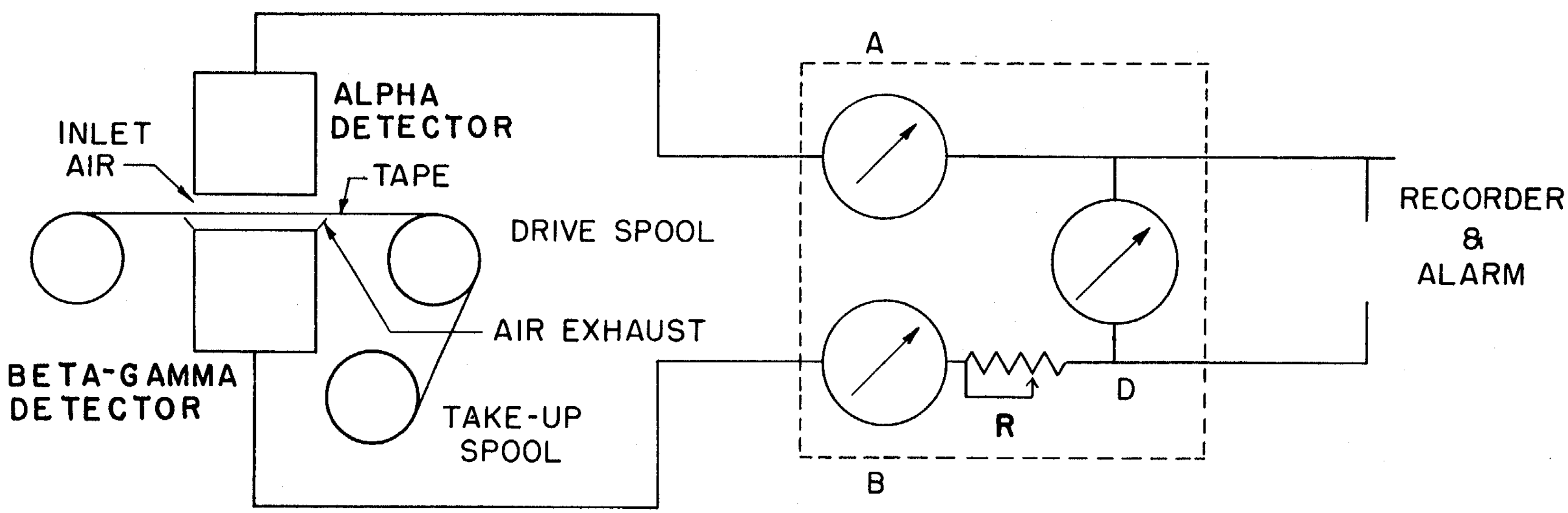

Fig. 4.31. Block Diagram Showing Principle of Operation of Differential Alpha to Beta-Gamma Ratio Continuous Air Monitor. The constant ratio of alpha-counting rate (A) to beta-counting rate (B) is adjusted to one by sensitivity control, R. Any deviation from this constant ratio is indicated by the difference meter, D.

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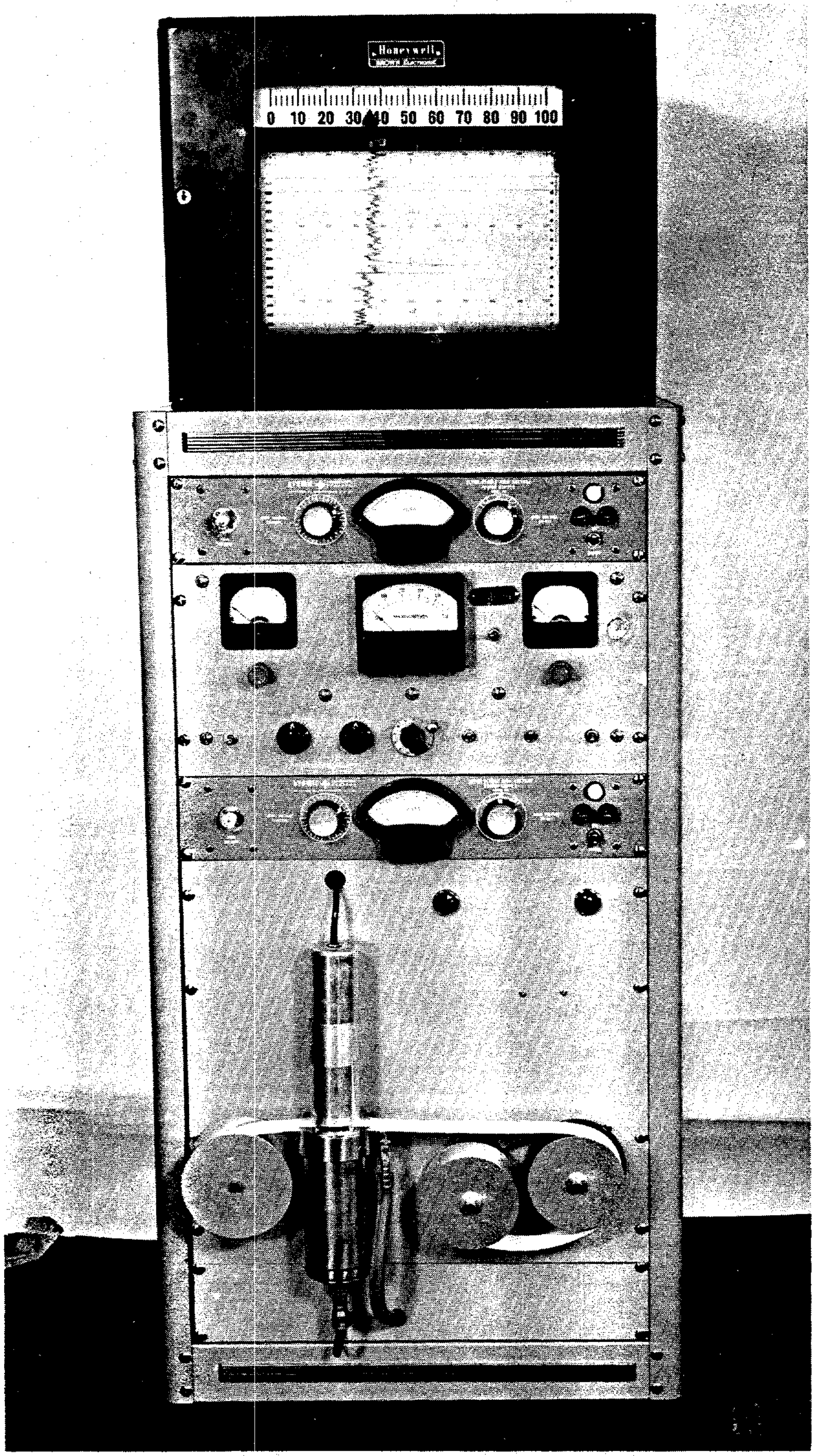

Fig. 4.32. Differential Type, Alpha to Beta-Gamma Ratio, Continuous Air Monitor Using the Moving Tape Concept.

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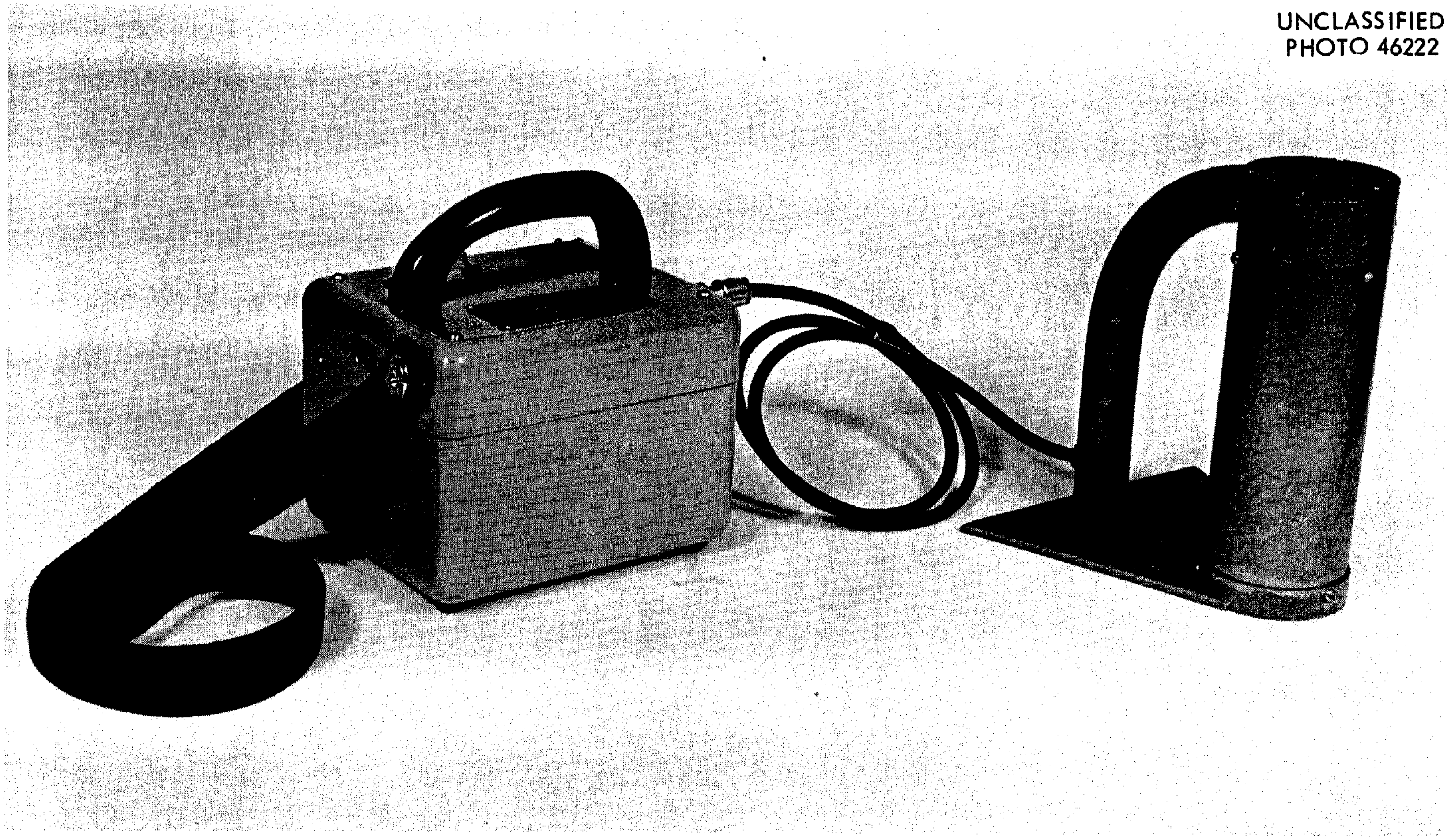

Fig. 4.33. Portable Alpha Scintillation Counter.

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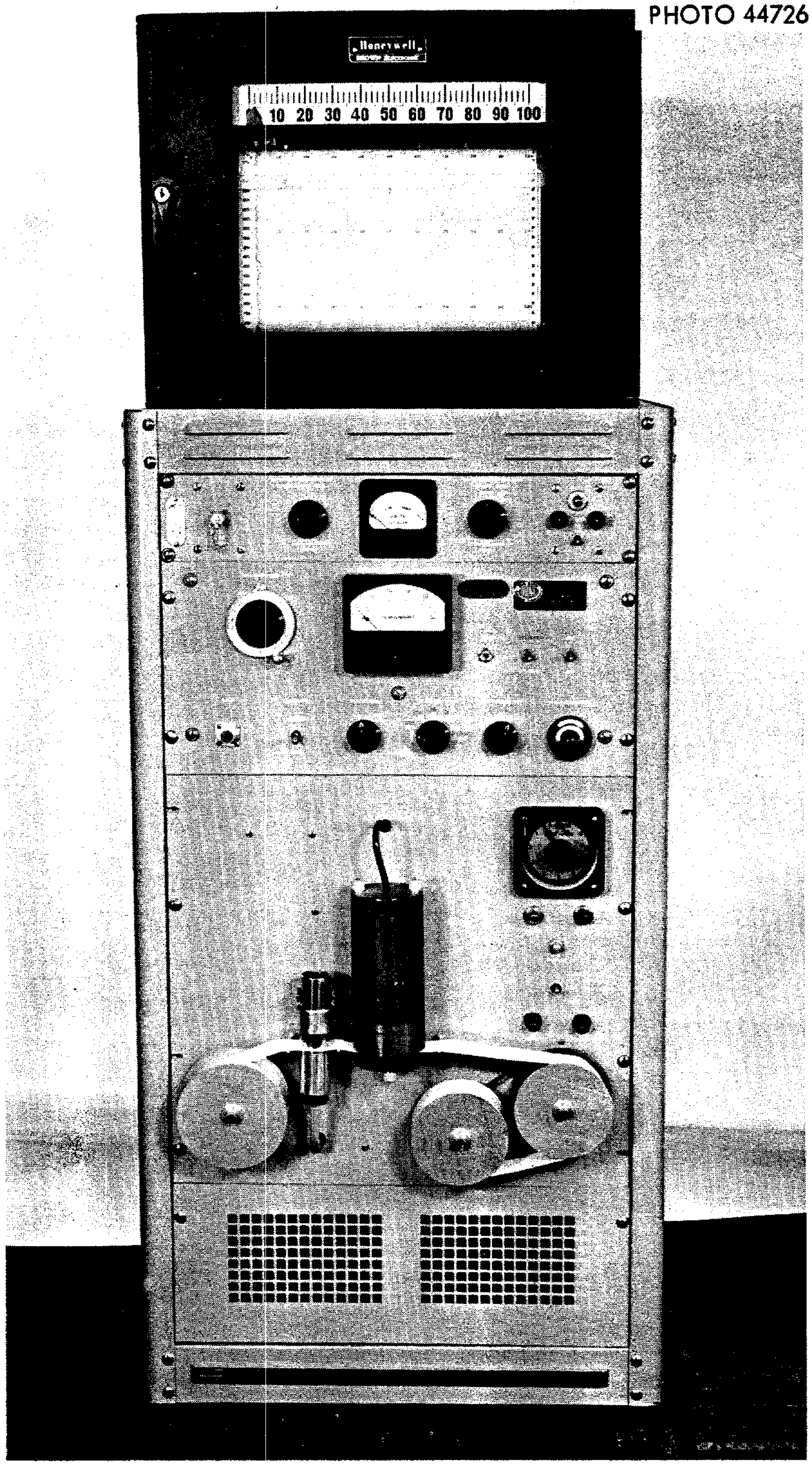

Fig. 4.34. An Automatic, Pre-Set Time Interval, Tape Type, Beta-Gamma Air Sampler.

5.0 Radiation Surveys

A. D. Warden R. L. Clark O. D. Teague L. C. Johnson

In 52 unusual incidents recorded at the X-10 and Y-12 sites, there was no significant external or internal exposure to personnel.

Of a total of 25 incidents in laboratories at the X-10 site, 16 recorded both personnel and building or equipment contamination, 5 were concerned with building or equipment contamination, and one involved a contaminated wound. Three incidents involved air-borne contaminants necessitating the evacuation of the buildings involved for a short time.

In 18 incidents reported for the X-10 reactors and pilot plants, 12 recorded both personnel and buildings or equipment contamination. Three incidents involved personnel contamination without detectable building or equipment contamination. Three incidents involved air activity, of which one necessitated evacuation of the building and one resulted in personnel and building contamination. Four of the 18 incidents occurred on shifts.

In nine incidents that occurred in the Y-12 area, one involved both personnel and building contamination and five involved only building or equipment contamination. The fact that the slurry loops in Bldg. 9204-1 are enclosed in adequate shields helped prevent personnel contamination. One incident involving air contamination and building surface contamination necessitated partial evacuation of one building. Two incidents concerned possible exposure to an external radiation source; contamination problems were not involved.

The scope of this report is such as to prohibit a detailed discussion of radiation incidents. However, all radiation incidents are described in detail and kept as a permanent record. Incidents of significance are as follows:

General Research, Chemistry, and Isotope Areas (X-10)

1. "Contamination Incident in Building 3550 (Old Chemistry Building", Jan. 10, 1958.
2. "Contamination Problems During Remodeling of Building 3508 (Isolation Lab.)", Feb. 1, 1958.
3. "Report of Radiation Incident in Building 4500", May 10, 1958.
4. "Contamination Incident in Shipping Area, Building 3038", March 21, 1958.
5. "Contamination Incident in Building 4500, C-1 Wing", May 23, 1958.
6. "Contamination Incident in Building 3508", July 8, 1958.
7. "Report of Radiation Incident in Building 4500", Aug. 8, 1958.
8. "Contamination of First Level, Building 4501", Aug. 8, 1958.
9. "Spread of Contamination in Building 4501", Aug. 13, 1958.
10. "Spill of U-233, Building 3550, Room (2)", Aug. 26, 1958.
11. "Building Contamination of 4501 with Particular Emphasis on the Corrosion Examination Facility of the REED Division", Sept. 4, 1958.
12. "Sr - Y^{90} Incident in Building 3038", Sept. 5, 1958.
13. "Radiation Incident, Building 4500, Lab. A-29", Sept. 8, 1958.
14. "Incident in Building 4505", Aug. 28, 1958.
15. "Spill in Wing 4, Building 4500", Sept. 10, 1958.
16. "Contamination of Street South Side of Building 4500", Sept. 12, 1958.
17. "Contamination Incident in Building 4501", Oct. 9, 1958.
18. "Plutonium Contamination at Building 3027 (SF Storage Vault)", Oct. 14, 1958.
19. "Contamination on Injured Hand", (Location; Building 3550, Room 2-A), Oct. 14, 1958.
20. "Contamination Incident, Building 4500, Lab. A-B-25", Nov. 4, 1958.
21. "Air Activity in Building 3030 (Isotope Area)", Nov. 11, 1958.
22. "Contamination of Personnel in Isotope Area", Nov. 13, 1958.
23. "Contamination Incident in Building 4501", Oct. 31, 1958.
24. "Contamination Incident in Building 4501", Oct. 31, 1958.

Reactors and Pilot Plants, X-10

1. "Unusual Incident Basement Area, Building 3019 (Hot Pilot Plant)", Feb. 10, 1958.
2. "Contamination Incident" (Location: Building 3019), Feb. 28, 1958.
3. "Spread of Contamination in Building 3001", Feb. 25, 1958.
4. "HRT Activity Incident, Building 7500", May 28, 1958.
5. "Unusual Incident in Cell 6, Building 3019", June 13, 1958.
6. "Incident Occurring in High Radiation Level Analytical Facility, Building 3019", June 25, 1958.
7. "Contamination Incident, Building 3019", June 13, 1958.
8. "Contamination Incident, Building 3019", July 16, 1958.
9. "Air Activity in Building 3001 (Graphite Reactor)", Aug. 26, 1958.
10. "Air Activity "G" Cell, Building 3505 (Metal Recovery)", Sept. 11, 1958.
11. "Contamination at HRLAF, Building 3019", Nov. 11, 1958.
12. "Contamination Incident in Building 3074 (Maintenance Shop)", Nov. 18, 1958.
13. "Activity Incident in West Room, Building 3005 (LITR)", Nov. 18, 1958.
14. "Contamination in Building 3019 (HRLAF)", Dec. 3, 1958.
15. "Incident at 7500 (HRT)", Feb. 25, 1958.
16. "Alpha Contamination of Employee, Building 3019", Aug. 21, 1958.
17. "Pu Contamination of Employee, Building 3505", Sept. 20, 1958.
18. "Personnel Contamination Received at HRT (7500)", Oct. 18, 1958.

ORNL Units at Y-12

1. "200 A-Loop Failure in Building 9204-1", May 23, 1958.
2. "Rupture of Germanium Target, 9201-2, Bio-Assembly Area", July 14, 1958.
3. "Survey of Cabinet at Elza Property Sales", July 28, 1958.
4. "High Pressure Loop Failure in Building 9204-1", Aug. 29, 1958.
5. "Incident Involving Thorium Oxide (Building 9204-1)", Sept. 9, 1958.
6. "Thorium Spill at Building 9204-1, Y-12", Sept. 26, 1958.

7. "Thorium Spill in Building 9204-1", Oct. 6, 1958.

8. "Incident at Source Building 9207 Area (Biology)", Nov. 7, 1958.

9. "Incident at 86" Cyclotron (Building 9201-2)", Nov. 11, 1958.

6.0 Reports and Papers

1. "Use of Light Aircraft for Surveying for Radioactive Ground Contamination", H. H. Abee, D. M. Davis, ORNL CF 58-5-98. Presented at Health Physics Conference, June, 1958.

2. "Personnel Monitoring Around a Reactor", D. M. Davis, ORNL CF 58-5-40.

3. "Personnel Meters", D. M. Davis, J. C. Hart, K. Z. Morgan, ORNL CF 58-12-39, Report to Four-Plant Steering Committee.

4. "Radiation Dose to Gonads from Diagnostic X-ray Exposure", E. D. Gupton, T. A. Lincoln, The Journal of the American Medical Association, January 18, 1959, Vol. 166.

5. "Detection of ThO_2 Contamination Simulated Cuts and Abrasions", D. G. Thomas and J. V. Hilyer, ORNL CF 59-1-35.

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